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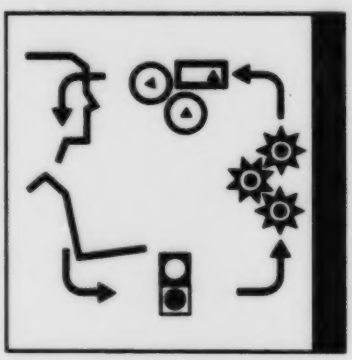
COMPTE RENDU du
SÉMINAIRE sur L'ERGONOMIE APPLIQUÉE
aux TRANSPORTS



14 October/octobre 1987
Montréal, Québec

Human Factors Association of Canada/
Association canadienne d'ergonomie

Transportation Development Centre
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COMPTE RENDU du
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14 October/octobre 1987

prepared by/préparé par

Ruth M. Heron
Leslie Buck

Human Factors Association of Canada/
Association canadienne d'ergonomie

for/pour
Transportation Development Centre
Centre de développement des transports

August/Août 1988

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The contents of these Proceedings reflect the views of the respective speakers and not necessarily the official views of either the Human Factors Association of Canada/ Association canadienne d'ergonomie or the Transportation Development Centre of Transport Canada.

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The talks are reproduced in the language in which they were presented. Both the opening session of the seminar and the closing panel discussion are presented in both official languages.

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17. Abstract

This report contains the papers/talks presented at the Seminar in Transportation Ergonomics held in Montreal on October 14, 1987, at the Guy Favreau Complex Conference Centre and co-sponsored by the Human Factors Association of Canada/Association canadienne d'ergonomie and the Transportation Development Centre of Transport Canada. The papers deal with a broad cross-section of ergonomics activities in all modes of transportation.

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	W.G. Rowan

17. Résumé

Ce document renferme les communications présentées lors du séminaire sur l'ergonomie appliquée aux transports, tenu à Montréal le 14 octobre 1987, au Centre des conférences du Complexe Guy-Favreau. Ce séminaire avait été parrainé conjointement par l'Association canadienne d'ergonomie/Human Factors Association of Canada et le Centre de développement des transports, Transports Canada. Les communications traitent d'un large éventail d'activités ergonomiques dans tous les modes de transport.

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FOREWORD

The concept of this seminar dates back to 1983 when one of us was working for the Transportation Development Centre (TDC), attempting to get an ergonomics capability established there. During the conduct of this work, it became clear that many transportation projects could profitably use the expertise of ergonomists, but within government and industry manager groups, there was uncertainty about how this young science should be applied. After all, its origin is set only as far back as World War II, and since then it has been utilized, at least on this continent, mainly by the military and the aerospace industry. Moreover, because of its multidisciplinary nature, its substantive content appears to be diffuse. And so it is little wonder that questions have arisen regarding the roles ergonomists might play on transportation project teams, the strategies they might use, and the utility of the kinds of information they can generate. On the other side of the coin, it also became clear during development of ergonomics at TDC that ergonomists in Canada wanted to learn how to gear their strategies to meet the needs of the transportation program developers.

What was needed, it then seemed, was an opportunity for transportation managers and Canadian ergonomists who had carried out work in the field of transportation to meet and discuss these matters. TDC was very enthusiastic about this idea, as was the Human Factors Association of Canada/ Association canadienne ergonomie (HFAC/ACE) when later approached about it. Ultimately, under the co-sponsorship of these two organizations, the idea became a reality as the Seminar in Transportation Ergonomics.

In discharging our responsibility for designing the seminar, we sought to maximize opportunity for dialogue between the two professional groups. The introductory address by Leslie Buck was intended to provide a framework within which the remaining presenta-

AVANT-PROPOS

L'idée d'un séminaire remonte à 1983; le CDT comptait alors dans ses rangs un collaborateur cherchant le moyen d'y créer des compétences en ergonomie. La recherche conduite par celui-ci a montré combien un point de vue ergonomique aurait été profitable dans un certain nombre de travaux de R&D en cours. Mais tant dans les milieux gouvernementaux que dans l'industrie privée, on ne savait pas encore très bien comment exploiter cette science naissante. Après tout, elle n'a vu le jour que pendant la Seconde Guerre mondiale et, depuis, du moins sur notre continent, elle a surtout servi dans les domaines militaire et aérospatial. Qui plus est, à cause de son caractère multidisciplinaire, son champ d'action leur paraissait flou. Il ne faut donc pas s'étonner des questions portant sur le rôle de l'ergonomie appliquée aux transports, sur les stratégies qui sont les siennes et l'utilité de l'information susceptible d'être fournie. De leur côté, les ergonomistes canadiens s'efforçaient de se mettre au diapason des promoteurs de systèmes de transport en adaptant leurs techniques et leurs stratégies aux besoins particuliers de ces derniers.

Il devint clair qu'il fallait donner aux spécialistes des transports ainsi qu'aux ergonomistes canadiens ayant oeuvré dans le domaine des transports, la possibilité de se rencontrer afin de procéder à des échanges d'idées. Cette occasion s'est présentée avec le séminaire que le CDT et l'Association canadienne d'ergonomie/ Human Factors Association of Canada (ACE/ HFAC) ont conjointement organisé avec enthousiasme.

Les organisateurs du séminaire ont voulu donner aux deux groupes de professionnels en présence toutes les occasions possibles de dialoguer. À commencer par l'exposé introductif de Leslie Buck qui situait ainsi le cadre par rapport auquel tous les exposés

tions could be interpreted. This framework was needed, we felt, to explain some of the basic principles of ergonomics, particularly its perspective regarding person/machine systems. In formatting the workshop portion of the seminar, our notion was to have presentations that, overall, would point up the diversity of areas in which ergonomists practise but, taken singly, would be brief enough to allow time for the all-important dialogue between groups while sufficiently detailed to stimulate that process. The panel/audience discussion at the end was considered necessary to provide a round-up of ideas and, hence, an overview of the seminar. For each workshop, speakers were selected from the ergonomist group, the chairperson from the manager group: for balance, and perhaps spice, this arrangement was reversed for the panel/audience discussion.

qui suivraient pourraient être situés. Il a fallu, bien sûr, expliquer certains des principes sur lesquels l'ergonomie se fonde, notamment l'approche globale qu'elle adopte par rapport à tout système homme-machine. Les ateliers étaient organisés de telle sorte que la plupart des exposés, dans leur ensemble, mettent en évidence la variété des domaines dans lesquels l'ergonomie s'exerce et qu'ils soient assez condensés pour laisser suffisamment de temps aux débats tout en renfermant assez de matière à réflexion pour nourrir les débats qu'on cherchait à amorcer entre les deux groupes en présence. Le débat de clôture a été vu comme un élément essentiel pour récapituler les idées et permettre un survol des interventions. Si, dans chaque atelier, les conférenciers se trouvaient être des ergonomistes, les présidents, eux, faisaient partie du groupe des gestionnaires. Au cours du débat, cet ordre a été inversé afin de rétablir l'équilibre et peut-être aussi ajouter du piquant à l'affaire.

We very much enjoyed our programming role in connection with the seminar and wish to thank and commend TDC for providing the opportunity for this first, and obviously exciting, exchange of information between Canadian transportation managers and ergonomists. In particular, we enjoyed our association with Wayne Rowan who, as Chairman of the TDC segment of the Organizing Committee (with Marcel Therrien as Display Coordinator, Dina Iwanycky as Public Relations Officer, Carole Beaupré as Secretary, and Marcelle Sadubin as Registration Receptionist), handled the burdensome secretariat function with efficiency and good will.

En ce qui nous concerne, nous avons rempli avec beaucoup de plaisir la tâche qui nous avait été dévolue et nous saisissons cette occasion pour remercier et féliciter le CDT d'avoir donné aux spécialistes des transports et aux ergonomistes canadiens cette première et combien passionnante occasion de se rencontrer et d'échanger des idées. Nous avons beaucoup aimé travailler avec Wayne Rowan qui, à la tête de l'équipe mise sur pied par le CDT pour organiser le séminaire (soit : Marcel Therrien, coordonnateur, Dina Iwanycky, agent de relations publiques, Carole Beaupré, secrétaire et Marcelle Sadubin, assistante aux inscriptions), s'est acquitté de ses fonctions avec beaucoup d'efficacité et de bonne volonté.

We should also like to thank Marc Brenckmann for his superb performance in the role of Program Chairman. We are grateful, as well, to all the other chairpersons for their fine supervision of their parts of the program, and to the speakers and exhibitors for their important contributions to program content.

Nous désirons également exprimer à Marc Brenckmann notre admiration pour sa prestation remarquable à titre de Président du séminaire et remercier par la même occasion tous les autres présidents, que ce soit ceux des ateliers ou du débat de clôture, ainsi que les conférenciers et les présentateurs des audio-visuels pour leur contribution au succès du séminaire.

People behind the scenes at HFAC/ACE also deserve words of appreciation, in particular, Executive Manager Peter Fletcher, Treasurer Lino Magagna, and Word-processor Doris Ainsworth.

These affairs, of course, are never accomplished without effort on the part of many people who contribute with seeming invisibility in small but essential ways. Finally, then, we are most grateful to all in this category.

Ruth M. Heron, Ph.D.,M.Erg.S.
(Chairperson, HFAC/ACE)

Leslie Buck, Ph.D.(Organizing Committee, HFAC/ACE)

Seminar in Transportation Ergonomics

Merci également à tous ceux de l'ACE/HFAC à Toronto qui ont si bien travaillé: Peter Fletcher, coordonnateur administratif, Lino Magagna, trésorier et Doris Ainsworth, traitement de texte.

Enfin, et comme toujours, il en est plusieurs dont la contribution, bien que petite, n'en a pas été moins importante. À tous ceux-là un grand merci.

Ruth M. Heron, Ph.D., M.Erg.S.
(Présidente, ACE/HFAC)

Leslie Buck, Ph.D. (membre du Comité organisateur, ACE/HFAC)

Séminaire sur l'ergonomie appliquée aux transports

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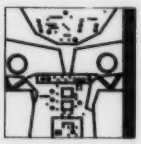

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OPENING OF SEMINAR

Introduction to Seminar

Chairperson — Marc Brenckmann,
Transport Canada

Mr. Brenckmann obtained a bachelor's degree in mechanical and aeronautical engineering in 1951 from ETH in Zurich, and a Master of Science from UTIAS in 1957. He has supplemented these degrees with courses in business administration from McGill, MIT, York, and various training centres.

Mr. Brenckmann's early employment comprised officer training in the French military service, and design and manufacturing engineering in various firms. In 1955, he joined De Havilland Aircraft where, first, he carried out work as a research engineer specializing in aeroelastics and structural dynamics, computer simulation and flight testing, and general testing and analysis of various STOL aircraft designs. Later, he managed a section engaged in advanced concept designs with respect to powered lift jet-STOL and VTOL concepts. From 1968 to 1970, he was in charge of the advanced project office, conducting the experimental work and the preliminary design for the DHC-7 concept.

In 1970, Mr. Brenckmann became manager of a section assigned to air transport projects at the Transportation Development Centre (TDC). Later he became the Associate Director at TDC, where he was responsible for the program planning activities for rail, marine, highway, and air transport research and development. In particular, he created the capability to undertake R&D in marine transportation, using and nurturing naval architecture and marine engineering expertise. All of this work brought him into close consultation and co-operation with industry and government organizations active in these transport sectors.

In 1985, he assumed his present position of Director, Research Program Development in the Research and Development Directorate of Transport Canada. In this capacity, he actively supports the Director General in the management of the department's central R&D activities which, including those at TDC, comprise some $30 million of annual expenditures.

His expertise in technical aeronautics and transportation, as well as in relevant R&D, is well known through his authorship of various papers and lectures. He is an Associate Fellow of the Canadian Aeronautical and Space Institute, and a member of the Advance Process Engineering Order and the Ordre des ingénieurs du Québec.

OUVERTURE DU SÉMINAIRE

Allocution d'ouverture

Président — Marc Brenckmann
Transports Canada

M. Brenckmann est diplômé en génie mécanique et aéronautique de l'ETH à Zurich (1951) et titulaire d'une maîtrise en sciences de l'UTIAS (1957). Il a également fait des études en administration des affaires aux universités McGill, MIT, York et ailleurs.

Après avoir été officier dans les forces armées françaises, il travailla comme ingénieur d'étude et de fabrication dans plusieurs entreprises. En 1955, il entra chez de Havilland où, à titre d'ingénieur de recherche, il a travaillé dans les domaines de l'aéroélasticité et de la dynamique des structures, la simulation assistée par ordinateur et les essais de vol, ainsi que dans celui de l'essai et de l'analyse de divers modèles d'ADAC. Plus tard, il dirigea des travaux sur des modèles avancés d'ADAC et d'ADAV et les réacteurs de sustentation. De 1968 à 1970, il conduisit des travaux de recherche expérimentale sur l'avant-projet du DHC-7.

En 1970, il est entré au Centre de développement des transports, où il dirigea une section chargée des projets de R&D en transport aérien. Plus tard, il fut nommé directeur adjoint du CDT, chargé de la planification des programmes de R&D concernant les transports ferroviaire, maritime, routier et aérien. À noter parmi ses réalisations, la mise en place des compétences nécessaires à la conduite de travaux de R&D en transport maritime — architectes et ingénieurs navals — qu'il a su développer et exploiter à bon escient. Tout ce travail a supposé de nombreuses consultations et une étroite coopération avec l'industrie et les organismes gouvernementaux concernés.

En 1985, il a assumé ses fonctions actuelles de directeur, Développement des programmes de recherche, Direction générale, Recherche et développement, Transports Canada. À ce titre, il assiste activement son directeur général dans la gestion des activités centrales de R&D de son ministère, lesquelles représentent, budget du CDT compris, des dépenses annuelles de quelque 30 millions de dollars.

Sa compétence en technique aéronautique et en transports, ainsi qu'en R&D dans ces secteurs, est largement reconnue grâce aux nombreux articles et communications dont il est l'auteur. Membre associé de l'Institut aéronautique et spatial du Canada, il appartient également à l'Advance Process Engineering Order et à l'Ordre des ingénieurs du Québec.

Good morning, ladies and gentlemen, fellow transportation researchers.

I'll take a few minutes to characterize the theme of the seminar and to set some of the guidelines for the proceedings.

As a long time specialist in transportation technology, I well remember the typical attitude of an engineer confronted with all the problems that you will encounter in transportation. The application of analysis, logic, special knowledge, technology, self confidence, etc., that is typical practice of a young engineer with some experience. Because transportation is a public service activity, we all at one point have to notice the growing importance of ergonomics in the everyday problems that we have to solve. These considerations are very often at odds with conventional engineering approaches. The problems and difficulties in implementing innovative systems in large part are identified from feedback from the users, the general public, the beneficiaries of the services being offered, and from personnel in charge of running the operations.

This describes the field of activity of ergonomics. Ergonomists have developed multi-disciplinary techniques to assist engineers in the technical resolutions of such problems. Thus this seminar affords participants an opportunity to get to know actual practitioners of this new science and remove any misunderstandings that may have developed between the two disciplines and even remove some of the notion of competition that may have arisen from time to time. It also presents an opportunity to explain how human factors can be understood, studied and woven into the technical solutions to be elaborated by engineers. Engineers should become a bit more discriminating in choosing and working with fully qualified ergonomists in various fields of interest.

Bonjour, mesdames et messieurs, chers collègues chercheurs du domaine des transports. Je m'appelle Marc Brenckmann et je préside ce séminaire.

Je vais consacrer quelques minutes à décrire le thème proposé à notre réflexion et vous renseigner sur la façon dont nous allons procéder.

Comme spécialiste de longue date en technologie appliquée aux transports, je me souviens bien de l'attitude typique d'un ingénieur en face de tous les problèmes qui se posent en transport. L'utilisation de l'analyse, la logique, les connaissances spéciales, la technologie, la foi dans le progrès, etc., qui caractérisent un jeune ingénieur avec expérience, et étant donné que le transport est une activité de service public, il nous arrive à tous de constater l'évidence croissante de l'impact des facteurs ergonomiques dans les problèmes que nous avons à résoudre, et ces facteurs sont souvent très récalcitrants aux méthodes d'ingénierie. Les problèmes et les difficultés dans les réalisations de techniques et de systèmes novateurs proviennent en grande partie des réaction causées chez les utilisateurs, le public en général, les bénéficiaires des services offerts, et le personnel de conduite des opérations.

En quoi consiste l'ergonomie? Les ergonomistes ont développé des techniques multidisciplinaires pour aider les ingénieurs à trouver des solutions à certains problèmes techniques. Ainsi, les ingénieurs qui assistent à ce séminaire auront l'occasion de rencontrer des spécialistes de cette nouvelle science qu'est l'ergonomie et de mieux la comprendre, éliminant du coup les malentendus, voire l'idée de concurrence, qui ont pu se développer entre ingénieurs et ergonomistes. C'est aussi l'occasion de comprendre ce que sont les facteurs ergonomiques, comment on les étudie et on les intègre dans la solution technique d'un problème. Mais un principe de base avant de poursuivre cette présentation: l'ingénieur doit bien choisir l'ergonomiste qualifié en fonction du domaine considéré.

So much for establishing the tone for the seminar. Let us all be time-conscious and stick to a tight schedule.

I would now like to make a few announcements. After the introductory remarks coming up immediately, and the keynote address that you've been waiting for, the program will consist of workshops, demonstrations and video presentations. The objective is to encourage you to interact with the different speakers and disciplines. So please do speak up, meet new faces, explore the displays, talk to exhibitors and visit the various demonstrations. Participate!

As you have noticed, translation service is available for all presentations in this room in both official languages. Some of the exhibits and demonstrations will be unilingual but people are available for on-the-spot translation. Those of you who wish to make use of the simultaneous translation service provided here for the main sessions can pick up headsets provided at the back of the room. Selection switch should be set for channel number one. During question periods, individuals are requested to go to one of the floor microphones, and identify themselves before asking their question to facilitate the business of keeping records.

Without further ado, I would now like to lead you through the program commencing with introductory remarks from the two sponsoring organizations of this event. First, I would like you to hear from Ted Rudback, who is the Executive Director of the Transportation Development Centre of Transport Canada.

Tel est donc le ton qu'il faut donner au séminaire. Mais ne nous laissons pas distraire de notre programme si chargé.

J'ai donc quelques recommandations à faire, après les introductions qui vont suivre immédiatement et le discours thématique que vous attendez, la programme consiste en ateliers, démonstrations et séances de vidéo. Ceci dans le but de vous mettre en interaction avec les différentes disciplines représentées. Donc, n'hésitez pas à prendre la parole, à entamer des dialogues, à suivre les audio-visuels et à parler avec les exposants. Bref, participez!

Comme vous le constatez, les présentations seront traduites dans les deux langues officielles. Même si certains audio-visuels sont unilingues, vous trouverez sur place des personnes bilingues prêtes à vous expliquer de quoi il s'agit. Les personnes qui veulent se prévaloir du service de traduction simultanée offert trouveront des écouteurs au fond de la salle. Pour obtenir la version traduite, il faut mettre le sélecteur sur le canal 1. Les gens qui désirent poser une question au conférencier sont priés d'aller à l'un ou l'autre des microphones placés dans la salle et de s'identifier avant de poser leur question, ce qui facilitera la tâche des personnes chargées de faire les procès-verbaux.

Sans plus tarder, commençons par l'allocution des deux personnes représentant les deux organismes parrains du séminaire. Voici donc en premier lieu Ted Rudback, directeur exécutif du Centre de développement des transports, de Transports Canada.

Sponsors' Remarks

N.E. (Ted) Rudback
(Executive Director, TDC):

Good morning, ladies and gentlemen. It's a great pleasure to welcome you to this seminar, organized and sponsored jointly by the Human Factors Association of Canada/Association canadienne d'ergonomie and the Transportation Development Centre (TDC) of Transport Canada. When we were first approached by HFAC/ACE to co-sponsor this seminar, it didn't take long to decide. TDC has been involved in ergonomics for a number of years and has managed many projects in this field. I would like to illustrate where ergonomics fits in our conception of things:

- ELECTRONICS,
- COMPUTERS,
- MATERIALS and
- ERGONOMICS

When we look at transportation development, we see driving or enabling technologies and disciplines that make things happen. I think we all would certainly recognize electronics, microchips, power electronics, fibre optics, etc. These types of developments are helping to make things happen. The fact is that we have tremendous computing capability at our fingertips. It is used in designing and developing systems. There are now great advances in software with expert or knowledge-based systems. Another important technology is materials with new ceramics, new composites, lubrication technology and lubricants and the exciting advances recently in superconducting technology.

Présentation des organismes parrains

N.E. (Ted) Rudback
(Directeur exécutif du CDT) :

Bonjour, mesdames et messieurs. C'est avec un grand plaisir que je vous souhaite la bienvenue à ce séminaire, organisé et parrainé par l'Association canadienne d'ergonomie et le Centre de développement des transports (CDT) de Transports Canada. Ce dernier, sollicité par l'Association canadienne d'ergonomie, n'a pas hésité à signifier son accord. D'ailleurs, cela fait plusieurs années que le CDT s'intéresse à l'ergonomie et qu'il conduit des travaux de R&D dans ce domaine. À ce propos, permettez-moi de vous dire où le CDT situe l'ergonomie dans sa conception des choses :

- ÉLECTRONIQUE
- INFORMATIQUE
- MATÉRIAUX
- ERGONOMIE

Sous l'angle du développement des transports, nous constatons qu'il existe des technologies et des disciplines de base ou pilotes. Je pense que nous serons tous d'accord sur l'électronique, les puces semiconductrices, l'électronique de puissance, les fibres optiques, etc. Elles sont à la base des progrès enregistrés. Il est un fait que nous disposons à l'heure actuelle d'une puissance de calcul formidable. On s'en sert pour concevoir et pour étudier des systèmes. Les logiciels ont, eux aussi, fait d'énormes progrès grâce aux systèmes experts à base de connaissances. Autre technologie de base, celle des matériaux comme les néo-céramiques, les matériaux composites, les nouveaux lubrifiants et la supraconductivité dont on connaît les progrès réalisés depuis quelque temps.

Transport Canada has a growing interest in maintaining a safe national transportation system for Canada. We believe it is one of the safest in the world and we are always striving to improve it. There is always a human operator in the transportation system and this is where ergonomics comes in. It cuts across these enabling technologies and touches all fields. The biggest single cause of operations-related accidents is not equipment fault or failure. It is generally human error. Ergonomics provides a better understanding of where humans fit into the system and how they react to various situations. If we want to continue to make advances, we've got to better understand this man-machine interface. It pays off not only in terms of safety, but also in improved efficiency.

With these few words on the role of ergonomics within TDC, I leave the floor to others who are more qualified in the field than myself. I want you all to have a good time today. I believe that you will find the seminar interesting, useful and beneficial. Thank you and good luck!

Marc Brenckmann:

Thank you, Mr. Rudback. I would now like to call on Ulrika Wallersteiner, President, Human Factors Association of Canada/Association canadienne d'ergonomie.

De plus en plus, Transports Canada axe son action sur la sécurité du réseau de transport canadien. À notre avis, ce réseau est l'un des plus sûrs du monde, mais il est perfectible. L'élément humain n'y est jamais absent, c'est pourquoi l'ergonomie a droit de cité. Elle rejoint toutes ces technologies de base et intéresse tous les domaines. La principale cause d'accidents, ce n'est ni la défaillance de l'équipement, ni les pannes; c'est en général l'élément humain. L'ergonomie apporte justement une meilleure compréhension de la place de l'élément humain dans tout système, en jetant un éclairage sur ses réactions face à ce système. Il ne pourra y avoir de progrès sans une meilleure maîtrise de l'interface homme-machine. On y gagnera non seulement en sécurité, mais aussi en efficacité.

Après ces quelques mots sur la place de l'ergonomie, je cède la parole à ceux qui sont plus qualifiés que moi pour en parler. Je suis sûr que vous trouverez ce séminaire intéressant, utile et profitable. Merci et bonne chance!

Marc Brenckmann :

Merci, M. Rudback. Et maintenant, je demande à Mme Ulrika Wallersteiner, présidente de l'Association canadienne d'ergonomie/Human Factors Association of Canada, de prendre la parole.
Madame, s'il vous plaît!

Ulrika Wallersteiner
(President, HFAC/ACE):

I feel very privileged to be able to address you here today as President of the Human Factors Association of Canada. As you know, the Human Factors Association of Canada is the professional organization of human factors/ergonomics researchers, practitioners, and associates. Much of our work in human factors/ergonomics deals with identifying the capabilities and limitations of the user-equipment interface. However, often we have no control over whether or not our recommendations are implemented. Many of you manage transportation related projects that involve operators and passengers. In many instances the way in which you evaluate any one project and the decisions which you make about that project will affect the performance of the operator and the well-being of the passengers for many years to come. In fact, you control the implementation of ergonomic recommendations.

Most of you who are attending this conference may have experienced by now the loss of a close friend or a family member. No matter how prepared you are for this event, you are never really ready when the parting does take place. We all know or are close to individuals who travel regularly by train, by car, or daily brave the roads of Montreal and other Canadian cities. Consequently, when the loss occurs instantly, such as in the Hinton train collision or the recent NorthWest flight in Detroit, it is devastating for the families affected. Not only is it devastating for the families of the accident victims, but it is also very difficult for the surviving operator of the vehicle. The operator will constantly relive the tragedy, asking what could have been done to avoid it.

Ulrika Wallersteiner
(Présidente, ACE/HFAC) :

C'est un grand honneur pour moi d'avoir, à titre de présidente de l'Association canadienne d'ergonomie/Human Factors Association of Canada (ACE/HFAC), à vous adresser la parole. Comme vous le savez, ACE/HFAC est un organisme qui rassemble les chercheurs et les praticiens de cette profession, ainsi que ceux des professions connexes. En ergonomie, la tâche principale est de rechercher où réside la force et la faiblesse de toute interaction homme-machine. Mais il arrive souvent que l'ergonomiste formule des recommandations sans avoir la certitude qu'elles seront prises en considération. Beaucoup d'entre vous êtes responsables de projets reliés à des systèmes de transport où il faut tenir compte de l'élément humain: opérateurs et passagers. Et ce sont eux qui, en fin de compte, seront les plus directement touchés par les décisions que vous serez amenés à prendre relativement au projet soumis à votre évaluation. C'est vous qui, en définitive, déciderez si telle ou telle proposition ergonomique sera suivie ou non.

Combien d'entre nous ici avons eu à déplorer la mort tragique de quelqu'un qui nous était cher, et quel a été le désarroi qui nous a envahi à la nouvelle de cette disparition! Un accident qui fauche la vie d'un être cher, y a-t-il rien de plus insensé, de plus désespérant! L'accident ferroviaire de Hinton ou, plus récemment, l'écrasement de l'avion de la Northwest Airlines à Detroit, quel malheur pour les familles éprouvées. Quel malheur aussi pour l'équipage ou le conducteur survivant. Sans cesse il revivra ce moment douloureux, revenant inlassablement sur sa responsabilité et sur ce qu'il aurait dû ou pu faire pour l'éviter.

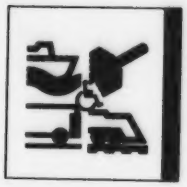
I firmly believe that in many instances there is no such thing as human error, just poor design. You and I can improve upon the design and therefore improve the performance of the operator. This will reduce the unnecessary death toll and make life safer. To prevent such accidents you must constantly challenge your thinking in your daily jobs in order to make ergonomically sound decisions that anticipate how the human interacts with the transport system and that minimize the number of adaptations that are forced upon the user. It has been said that the car changed the way we live and the way in which we experience the world. I think that this conference will change the way in which you will look at transportation. I think that you may also find the answers to your problem of reducing the number of accidents daily occurring in Canada, and increase the effectiveness of the person who's operating the vehicle. I ask you to listen closely to the speakers. The information that they provide can increase transportation safety. Ultimately you share in the responsibility because of the decisions you make. You are the implementors of human factors/ergonomics principles.

I would like to thank Ruth Heron and Leslie Buck who represented the Human Factors Association of Canada in the organization of this conference, and I would also like to thank Mr. Rudback and Mr. Rowan from the Transportation Development Centre of Transport Canada for providing us with this particular day. I hope you enjoy the day and learn from it.

J'ai la ferme conviction que très souvent l'erreur n'est pas dans l'homme mais dans un concept vicié à la base. Or, nous qui sommes ici avons la responsabilité de traquer de tels vices et celle d'améliorer la performance des systèmes, pour qu'il y ait justement moins de ces accidents insensés et pour que notre vie à tous devienne plus sûre. Votre défi, votre responsabilité au travail n'est-elle pas de réfléchir sur la meilleure façon de cerner le comportement humain devant tel ou tel système de transport, de démonter les rouages de l'interaction homme-machine, de réduire au minimum les adaptations exigées de l'opérateur? De même que l'automobile a profondément transformé notre manière de vivre, de même ce colloque est-il appelé à modifier profondément votre manière d'envisager désormais le monde des transports. Vous y trouverez, en plus, des réponses au problème des accidents qui fauchent tant de vies et à celui du relèvement des performances. Il suffira d'écouter les spécialistes qui se présenteront devant vous. Ce qu'ils auront à vous dire est directement relié à la sécurité des transports. La sécurité est une responsabilité et elle est en partie la vôtre parce que c'est vous qui décidez si les principes d'ergonomie sont à prendre ou à laisser.

Je saisis cette occasion pour remercier Ruth Heron et Leslie Buck qui ont été les porte-parole de ACE/HFAC auprès des organisateurs du colloque, ainsi que Messieurs Rudback et Rowan du Centre de développement des transports pour nous avoir fourni une occasion si propice. Je vous souhaite à tous une journée à la fois agréable et fertile en enseignement.

KEYNOTE ADDRESS



What is Ergonomics and What Can It Do for Transportation?

Leslie Buck

National Research Council of Canada, Ottawa

Dr. Buck graduated with a B.Sc. in psychology from the University of London in 1952. From 1954 to 1967 he was a scientific officer of the Industrial Psychology Research Unit of the UK Medical Research Council, and since 1967 he has been a research officer at the National Research Council in Ottawa.

From 1958 to 1967 he carried out several studies of various aspects of train driving on British Railways. This research was initiated when the accident inspection officers of the United Kingdom Ministry of Transport asked the Medical Research Council and the then British Transport Commission to set up a Joint Committee on Human Factors in Railway Accidents. It involved him in a great deal of direct observation of locomotive engineers and culminated with a study of vigilance devices which formed the basis of his 1967 dissertation for the degree of Doctor of Philosophy at the University of London.

From 1971 to 1974 he carried out a study of the effects of time zone change on commercial air crew. This also involved extensive direct observation of flying personnel.

In 1973 he was involved with the first of several studies of air traffic control, which have continued until the present. These have mainly dealt with the design of displayed information.

In 1986 he was chairman of a Technical Committee of the Human Factors Association of Canada/Association canadienne d'ergonomie which presented evidence to the Commission of Inquiry into the Hinton Train Collision.

DISCOURS-PROGRAMME

Qu'est-ce que l'ergonomie et quels sont ses apports en transports?

Leslie Buck

Conseil national de recherches, Ottawa

Titulaire d'un B.Sc. en psychologie obtenu à l'Université de Londres en 1952, M. Buck occupe de 1954 à 1967 un poste d'agent scientifique au sein du Industrial Psychology Research Unit of the UK Medical Research Council. Depuis 1967, il est agent de recherche au Conseil national de recherches à Ottawa.

Entre 1958 et 1967, il a réalisé plusieurs études sur divers aspects de la conduite des trains pour la société des chemins de fer British Railways. Cette recherche avait été lancée à la demande des services d'enquête sur les accidents du ministère des Transports du Royaume-Uni, lequel souhaitait que le Medical Research Council et la British Transport Commission du temps créent un comité conjoint d'étude des facteurs humains dans les accidents ferroviaires. Ces travaux ont comporté un important volet d'observation directe des conducteurs de locomotive et ont débouché sur l'étude de dispositifs de veille dont les principes ont formé la base de la thèse de doctorat que M. Buck a défendue à l'Université de Londres en 1967.

De 1971 à 1974, il a étudié les effets du décalage horaire sur les équipages de transport aérien. Cette étude comportait également une observation directe poussée du personnel navigant.

En 1973, il a participé à la première d'une série d'études sur le contrôle de la circulation aérienne qui se poursuivent toujours. Ces études ont concerné principalement la présentation des données utiles aux contrôleurs de la circulation aérienne.

En 1986, il a présidé un comité technique de l'Association canadienne d'ergonomie, qui a témoigné devant la Commission d'enquête sur la collision ferroviaire de Hinton.

He is a founding member of the Human Factors Association of Canada/Association canadienne d'ergonomie and since 1983 has been the secretary of the Association.

Since 1984 he has been a member, and secretary, of the National Research Council's Associate Committee on the Occupational Applications of Ergonomics Research.

Il est un des membres fondateurs de l'Association canadienne d'ergonomie et occupe depuis 1983 le poste de secrétaire de cette association.

Depuis 1984, il est membre et secrétaire du Comité associé de l'application professionnelle des recherches en ergonomie du Conseil national de recherches.

Ergonomics is a way of looking at human operators and how they do their work.

Ergonomics is indispensable because all artificial systems have human operators. Nature can get on without human operators — no one has to switch on the sun each morning — but no artificial system is entirely autonomous: even if no one is carrying out minute by minute operations, someone had to conceive the system, design it, construct it, and set it going, and someone has to monitor it, maintain it, and put it right if anything goes wrong. In other words somewhere in the system there is a person.

Ergonomics takes a system-oriented approach. The role of the human operator cannot be fully understood without understanding the other components of the system. Conversely, if we understand the mechanical, electrical, structural, and organizational components of the system, but not the human component, then we have an incomplete understanding of the system as a whole. All components must be seen and understood in relation to each other.

Ergonomics is multi-disciplinary. Human operators are themselves complex systems and require study from several different points of view. This means recourse to kinesiology, biomechanics, physiology, anatomy, and perceptual, cognitive, motivational and social psychology. The system-oriented approach also implies some knowledge of the various branches of engineering. The aim of the ergonomist is to bring all these sources of knowledge into a single focus: the function of the operator within the system (figure 1).

L'ergonomie est une manière d'envisager le travail des opérateurs humains et la façon dont ils l'accomplissent.

L'ergonomie est une discipline indispensable puisque dans tous les systèmes artificiels, des opérateurs humains interviennent. La nature se passe de l'homme : le soleil n'a pas besoin de quelqu'un pour se lever chaque matin; d'un autre côté, il n'existe aucun système artificiel qui soit complètement autonome. Tout système aussi automatique qu'il puisse être doit pourtant être conçu, réalisé, mis en marche, surveillé, réparé et entretenu par quelqu'un. Bref, il doit avoir à un moment donné des relations avec les humains.

L'approche ergonomique est d'abord systémique. En effet, l'aspect humain de n'importe quel système ne saurait être envisagé en faisant abstraction des autres aspects du système : mécanique, électrique, structurel et organisationnel. Inversement, aucun de ces aspects ne saurait être appréhendé complètement si l'aspect humain était tenu à l'écart. Donc, tous les constituants d'un système doivent être vus et compris dans leurs relations les uns avec les autres.

L'approche ergonomique est aussi multidisciplinaire puisque l'opérateur humain peut être assimilé à un système éminemment complexe. Pour l'étudier dans son ensemble, il faut avoir recours à la kinésiologie, la biomécanique, la physiologie, l'anatomie, la psychologie de la perception, de la cognition et de la motivation ainsi qu'à la psychologie sociale. Le mode d'approche systémique sous-entend, en outre, des connaissances dans les diverses techniques de l'ingénierie. Pour l'ergonomiste, il s'agira avant tout de focaliser toutes ces disciplines sur un seul but : le rôle de l'opérateur à l'intérieur du système (figure 1).

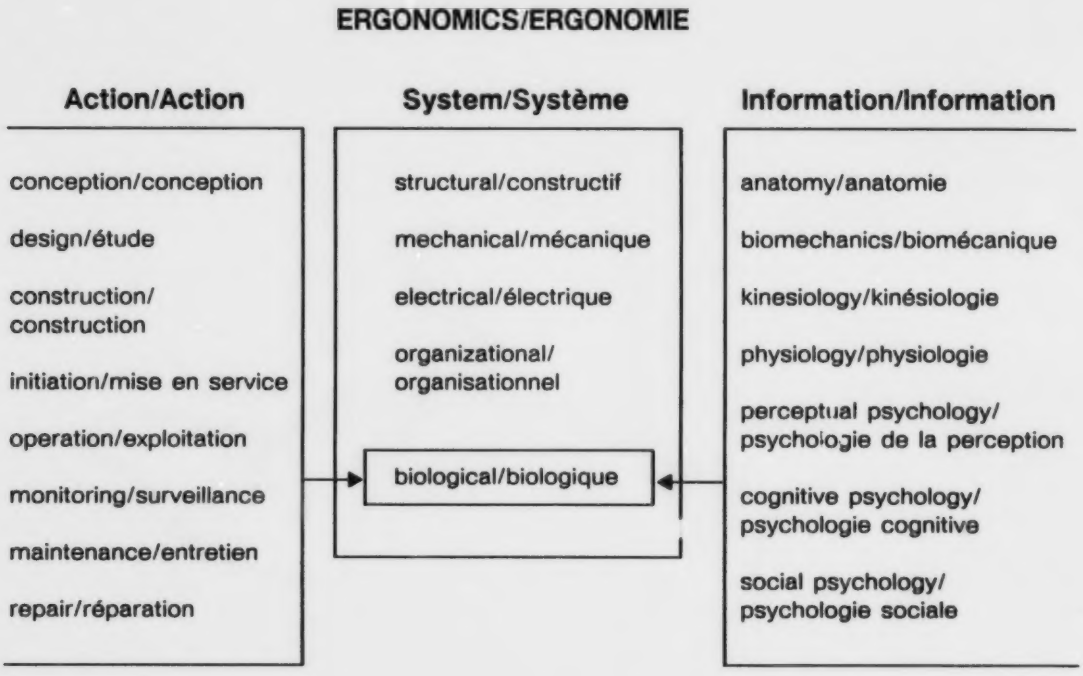


Figure 1
The human operator plays an indispensible role as a component of the total system, and various kinds of expertise are needed to understand all aspects of that component.

Figure 1
On ne saurait envisager un système complet sans envisager en même temps l'élément humain qui lui est indispensable, et, pour l'appréhender, il faut recourir à des disciplines très diverses.

Ergonomics deals with specific problems. Today's seminar is devoted to accounts of various studies carried out by ergonomists in the realm of transportation. They are all specific but they all involve ergonomics, and the aim of this paper is to give an overall conceptual framework within which these different studies can be placed. In this way we hope to get across the idea of an indispensable, system-oriented, multi-disciplinary approach to the human operator in transportation.

L'ergonomie traite de questions spécifiques. Durant le séminaire, il sera question des applications de l'ergonomie au domaine des transports. Les études présentées concernent toutes des sujets spécifiques mais, elles les abordent sous l'angle de l'ergonomie. Notre but consiste à développer le cadre conceptuel à l'intérieur duquel s'intégrent toutes les notions mises de l'avant dans ces études. Nous espérons de cette façon faire accepter l'idée qu'une approche systémique et multidisciplinaire à la définition du rôle de l'opérateur dans les systèmes de transport est indispensable.

Information-processing

The term "operator" means all kinds of persons doing all kinds of work: machine operators, maintenance workers, musicians, managers, lawyers, agricultural workers, nurses, pilots, helmsmen, locomotive engineers, truck drivers, air traffic controllers, dispatchers, and traffic police. We want to be able to analyze the way operators perform their tasks, using a coherent and integrated technique that can be applied to many different circumstances.

Ergonomists use a model based on information-processing theory, and its origins can be traced to the impact that the mathematical theory of information had upon psychology in the 'forties and 'fifties. Before that time the theoretical approach to human operators was somewhat different, a point to which I shall return later. For the moment we shall examine this information-processing model.

The basic idea of the information-processing model is that performing a task involves an exchange of information between the operator and the rest of the system. In simple terms, the operator needs to know the current and desired states of the system and what to do in order to reduce the difference between the two. Figure 2 illustrates this idea applied to the case of a locomotive engineer driving a train, although it could be applied equally well to a pilot or a helmsman or a truck driver or an air traffic controller or anyone in transportation.

Traitement de l'information

Le terme "opérateur" désigne toutes les personnes s'adonnant à une activité quelconque : machinistes, réparateurs, musiciens, directeurs, avocats, travailleurs agricoles, infirmières, pilotes, timoniers, conducteurs de trains, chauffeurs de camions, contrôleurs de la circulation aérienne, agents de régulation et agents de la circulation routière. Les ergonomistes cherchent à analyser comment ces personnes s'acquittent de leur tâche, utilisant pour cela une méthode cohérente et intégrée qui est conçue pour s'adapter à toutes les situations étudiées.

Les ergonomistes se servent d'un modèle fondé sur le traitement de l'information dont l'origine peut être reliée à l'impact de la théorie mathématique de l'information sur la psychologie dans les années 40 et 50. Auparavant, la question de l'opérateur était abordée dans une autre optique théorique que j'expliquerai plus tard. Pour le moment, examinons de près ce modèle d'analyse basé sur le traitement de l'information.

Il se fonde sur le principe que toute activité nécessite un échange d'informations entre les éléments qui composent un système, y compris l'opérateur. En termes simples, celui-ci a besoin de connaître l'état actuel du système et celui qui est souhaité, afin de savoir ce qu'il doit faire pour réduire l'écart entre ces deux états. La figure 2 illustre cette idée appliquée à un conducteur de locomotive, bien que ce schéma soit tout aussi bien applicable à un pilote d'avion, un timonier, un chauffeur de camion, un contrôleur de la circulation aérienne ou tout autre opérateur dans un système de transport.

INFORMATION-PROCESSING MODEL
MODÈLE DE TRAITEMENT DE L'INFORMATION

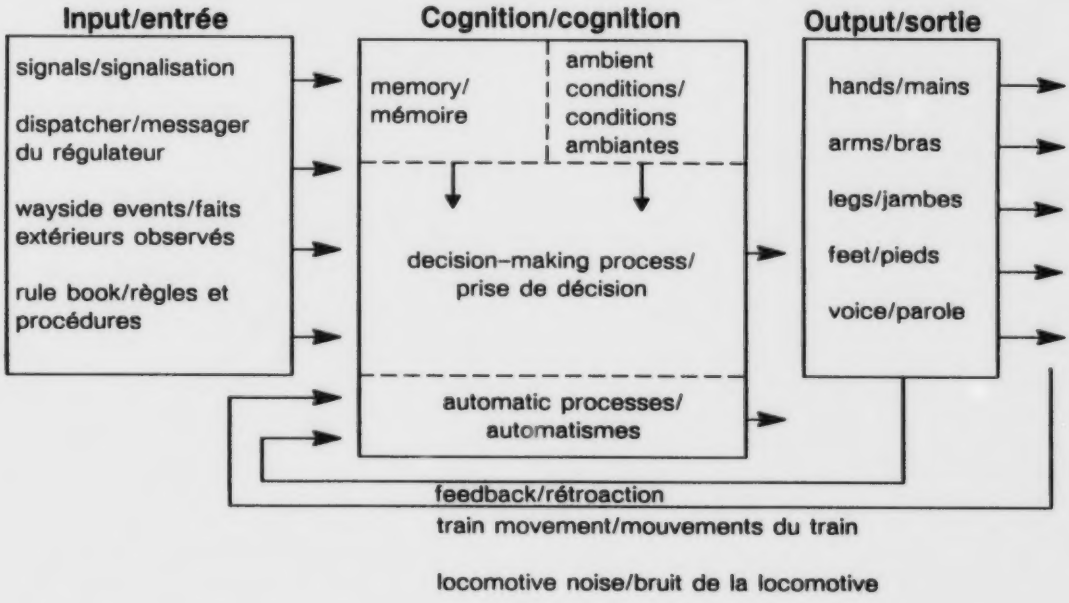


Figure 2
The information-processing model provides a method for analyzing the task of the locomotive engineer.

Figure 2
Ce modèle de traitement de l'information permet d'analyser la tâche d'un conducteur de locomotive.

We can demonstrate that anything which impedes this exchange of information reduces the efficiency of the system: either performance suffers, or the operator is subjected to debilitating stresses, with the result that the system is inefficient and ultimately breaks down, and accidents occur (figure 3).

Il est facile de démontrer que tout ce qui gêne l'échange d'information abaisse forcément l'efficacité du système : ou c'est le rendement qui tombe ou alors c'est l'opérateur qui est mentalement surchargé; le résultat final ne peut être que la défaillance du système, voire un accident (figure 3).

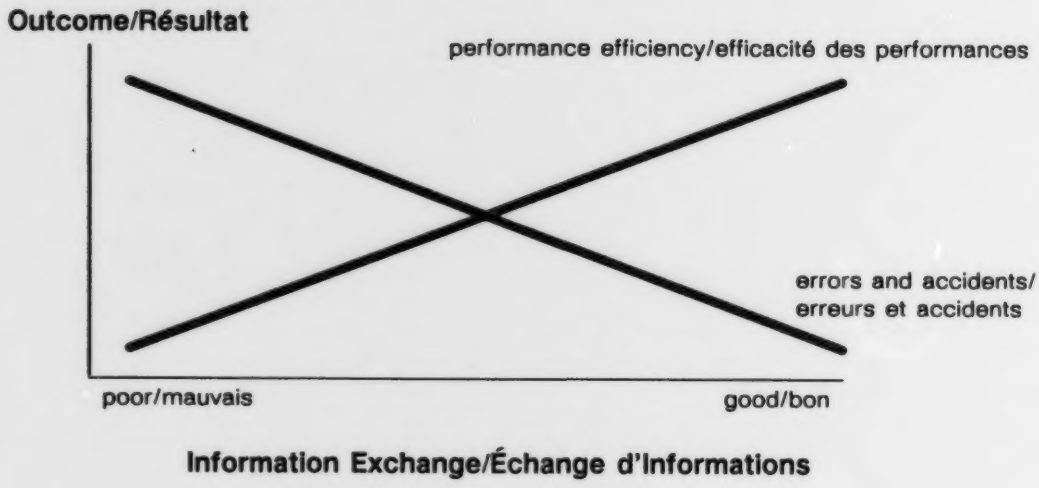


Figure 3
When information exchange between the operator and the rest of the system is at an optimal level performance is more efficient, fewer errors are made, and accidents are avoided.

Figure 3
Lorsque l'information s'échange de façon optimale entre l'opérateur et le système, l'efficacité en est accrue, les erreurs sont moins fréquentes et les risques d'accident éliminés

Along with this, and equally important, we have to bear in mind that this exchange of information takes place in a certain physical, psychological and social context. These contextual factors also affect the efficiency with which the task is performed, and can, in certain circumstances, lead to the same kinds of operator stress and system breakdown (figure 4).

Mais cet échange d'information se produit nécessairement dans un environnement physique, psychologique et social particulier, qu'il ne faut certes pas négliger et qui influe tout autant sur l'efficacité du système. Tous ces facteurs d'environnement peuvent alors, dans certaines circonstances, mener aux mêmes conséquences néfastes (figure 4).

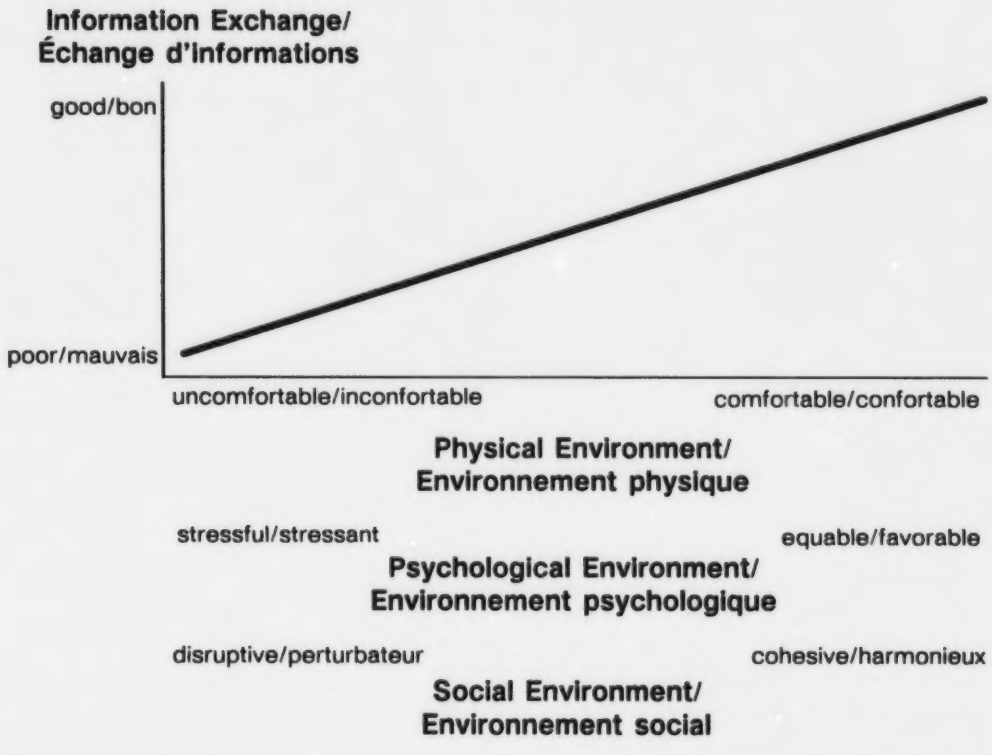


Figure 4
Various aspects of the working environment affect information exchange between the operator and the rest of the system.

Figure 4
Les milieux ambiants ont une grande influence sur l'échange d'information qui a lieu entre l'opérateur et le système.

The tasks of the ergonomist therefore are to analyze all of these factors and, within the scope of the prescribed investigation, to specify how the system can be changed or re-designed in order to improve performance and reduce stress.

Le rôle de l'ergonomiste sera donc d'analyser l'ensemble de ces facteurs et, dans le cadre du mandat qui lui a été confié, de proposer des correctifs susceptibles de relever l'efficacité ou de réduire les niveaux de stress.

Display Interface

Figure 5 outlines the elements of this model, starting with the display interface by which operators know the state of the system. This refers not only to all that operators see in order to perform the task, but also all that they hear, feel and smell and in fact anything known by virtue of the senses. For locomotive engineers, the display interface includes all of the instruments, gauges, documents and devices provided for their use, both within the cab and outside it. We can call these the formal sources of information, remembering that locomotive engineers also use many informal sources like the noise of the locomotive engine, the vibration of the locomotive moving along the track, echoes from passing structures and so on. Sometimes informal sources can be enhanced, becoming almost like instruments (figure 6). An example in the context of locomotive operation (steam locomotives, at least) is a fluid-level glass. Other everyday examples of this technique are the edge and centre markings painted on to road surfaces.

Interface de visualisation

La figure 5 schématise le modèle mentionné plus tôt. Commençons par l'interface de visualisation grâce à laquelle l'opérateur peut connaître l'état actuel du système. Pour l'exécution de sa tâche, il fait appel non seulement à tout ce qu'il voit, mais aussi à tout ce qu'il entend, touche et sent, bref tout ce qu'il peut saisir grâce à ses organes sensoriels. Pour le conducteur de locomotive, le dispositif de visualisation comprend tous les instruments, cadrans, documents et dispositifs à sa disposition, tant à l'intérieur qu'à l'extérieur de la cabine. Ils constituent ce qu'il est convenu d'appeler les signaux formels, par opposition aux nombreux signaux informels également utiles au conducteur, tels que bruit du moteur, vibrations engendrées par le déplacement de la locomotive sur la voie, échos des ouvrages d'art franchis; etc. Il est parfois possible de rehausser les signaux informels pour en faire autant de sources d'information quasi-formelle (figure 6). Dans les locomotives, par exemple, du moins dans celles à vapeur, l'indicateur de niveau joue ce rôle. Autre exemple de tous les jours, les marquages de chaussée qui repèrent l'axe et les bords de la route.

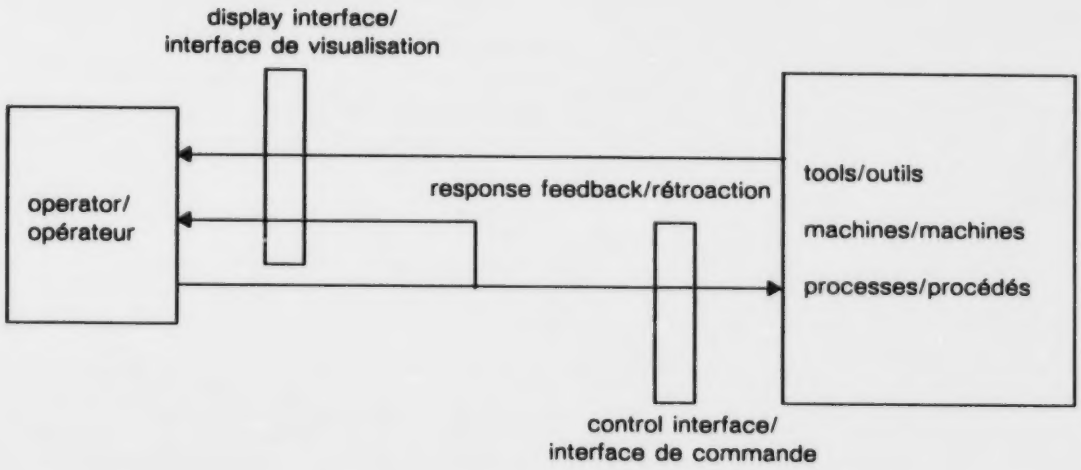


Figure 5
Information exchange between the operator and the rest of the system takes place through the display interface and the control interface.

Figure 5
Les échanges d'information entre l'opérateur et le système se produisent par l'intermédiaire de l'interface de visualisation et de l'interface de commande.

SOURCES OF INFORMATION/
SOURCES D'INFORMATION

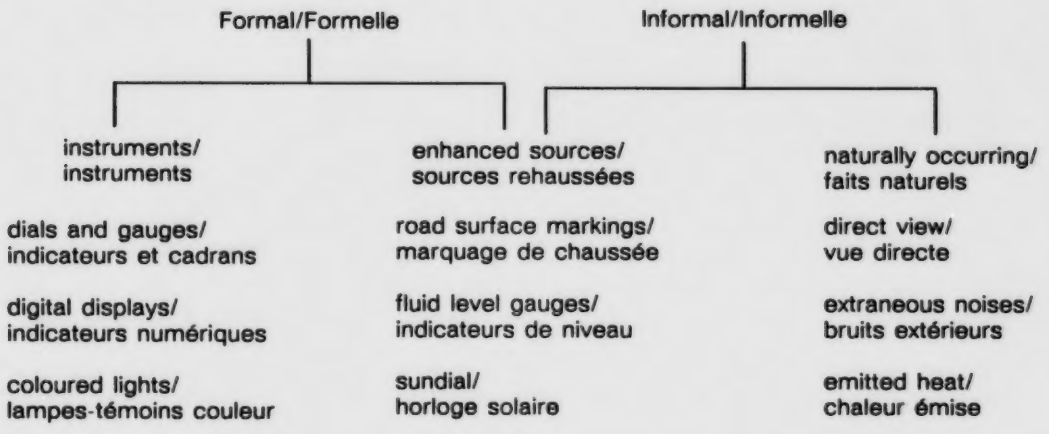


Figure 6
The display interface includes several categories of component.

Figure 6
L'interface de visualisation se décompose en de nombreux éléments.

Having identified these sources of information we can then evaluate them (figure 7). This requires an understanding of human perceptual processing, the critical point being that being able to do it (that is, perceive information) does not mean that one necessarily knows how it is done.

Après avoir reconnu les diverses sources d'information, nous pouvons maintenant les évaluer (figure 7). Pour cela, il faut savoir comment se déroule le processus de la perception chez l'homme et comprendre que percevoir l'information ne signifie pas nécessairement savoir comment cela se passe.

HOW GOOD IS THE DISPLAY INTERFACE
QUALITÉ DE L'INTERFACE DE VISUALISATION

- What information does the operator use in performing the task?
- Quelles sont les informations utiles à l'opérateur dans l'accomplissement d'une tâche donnée?

- What are the sources of this information?
- Quelles sont les sources de ces informations?

-- Does the display present the information in the most efficient, reliable and adequate manner?
- Est-ce que la présentation pourrait être plus efficace, fiable et appropriée?

- Is there information which the operator needs or could use which the display does not provide?
- Existe-t-il des informations nécessaires ou utiles à l'opérateur mais non fournies par la visualisation?

Figure 7
Evaluating the display interface

Figure 7
Évaluation de l'interface de visualisation

To take a simple example, locomotive engineers must from time to time estimate distance to a far object (a wayside signal, for example), and this looks easy enough. However, a commonly used cue for perceiving distance is clarity (unclear objects are seen to be further away), and clarity depends upon visibility as well as distance. Failure to take account of visibility may lead to an error in estimating distance.

Par exemple, le conducteur d'une locomotive doit, de temps à autre, estimer la distance qui le sépare d'un objet, disons un feu en bordure de voie. Cela peut sembler facile, mais il faut se rappeler que cette estimation dépend de l'évidence du signal, elle-même fonction à la fois de la visibilité et de la distance. On sait qu'un objet semble être d'autant plus éloigné que son évidence est faible. Aussi, le fait de négliger le facteur de visibilité peut-il entraîner une erreur dans l'estimation de la distance.

The problem, from an ergonomics point of view, is to ascertain how the error happens, and then to see how the display interface can be changed in a way to eliminate, or at least to reduce, the possibility of its happening again. One may argue that the locomotive engineer should be aware of such problems and so not make the error, but saying that errors should not happen is not always a very helpful approach. A better one may be to re-design the interface.

Pour résoudre ce problème, l'ergonomiste voudra tout d'abord déterminer comment l'erreur se produit et, ensuite, décider par quel moyen en modifiant l'interface de visualisation, elle pourra être éliminée ou du moins réduite. Certains soutiendront que c'est l'affaire du conducteur de ne pas faire ce genre d'erreur. À mon avis, ce n'est pas là une approche très utile et modifier l'interface serait, sans doute, plus efficace.

The point can be more forcibly made in the case of true illusions, where things are really seen to be other than they are. In the moon illusion, for example, the moon appears to be much bigger just after rising than when it is higher above the horizon, an illusion that has been ascribed to the effects of refraction. However, knowing how it is caused makes it no less compelling. In any case refraction does not explain the moon illusion because it can be produced experimentally in situations where refraction does not occur, showing that the cause lies in the observer's perceptual processes, not in the physical conditions. More to the point, there is documented evidence in air transportation that illusions like this have led to accidents.

Le bien-fondé de la position de l'ergonomiste devient encore plus frappant quand on considère le cas des phénomènes d'illusion optique qui sont réellement trompeurs. Lorque la lune se lève, par exemple, on remarque qu'elle semble beaucoup plus grosse que lorsqu'elle se trouve bien au-dessus de l'horizon; certains expliquent ce phénomène par la réfraction. Toutefois, trouver une explication du phénomène ne le rend pas moins curieux; de toutes façons, la réfraction n'est pas à l'origine de cette illusion. En effet, on a réussi à la reproduire expérimentalement sans faire intervenir la réfraction, preuve que c'est le processus perceptif de l'observateur qui est en faute et non la réalité physique. Mais, plus important pour nous, est le fait que des accidents aériens se soient produits justement à cause de tels phénomènes d'illusion optique.

There is more to perception than meets the eye. Uninformed suppositions about what information an operator gets from any particular visual presentation are likely to lead us into trouble. The same can be said even more strongly for auditory and vibratory presentations.

La perception est un processus beaucoup plus complexe qu'il n'y paraît à première vue. On se doute à quel point il peut être dangereux de se baser sur une interprétation erronée de ce qu'une telle interface de visualisation est supposée fournir comme information à l'opérateur. C'est encore plus vrai lorsqu'il s'agit de sensations auditives et vibratoires.

A supposedly simple solution is to replace informal sources of information by formal sources, as when locomotive engineers were provided with speedometers instead of being left to rely on their judgments of the speed of passing objects. This, however, introduces new questions relating to the design of instruments, examples of which abound in ergonomic textbooks: optimal size, scale markings, analog versus digital form, fixed scale or fixed pointer, and so on. There are, in fact, no easy solutions.

Une solution supposément simple serait de remplacer les signaux informels par des signaux formels, comme ce fut le cas lorsque les locomotives ont été équipées d'un indicateur de vitesse pour que les conducteurs ne soient plus astreints à se fier à leur seule perception pour évaluer la vitesse du train. Mais cette substitution a soulevé à son tour de nouvelles questions concernant la conception des instruments : taille, repères, forme analogique ou numérique, aiguille mobile ou cadran mobile, etc. Les exemples cités dans les ouvrages sur l'ergonomie sont nombreux. Mais, en fait, il n'existe pas de solution simple.

Control Interface

The next element in the model to consider is the way in which the operator changes the state of the system. This is directly analogous to the flow of information from the system to the operator. In this case information flows from the operator to the system causing it to adopt a new one of its possible states, bearing in mind that doing nothing — maintaining the existing state — is one possible option. The channel for information exchange is the control interface (figure 5).

Again we can start by enumerating and evaluating all of the control devices provided for the purpose: levers, knobs, switches, valves and so on (figure 8). As with the display interface some of these devices may be informal in character. One can imagine that on steam locomotives, at least, the engineer might have modified the state of the mechanical system by means of well-placed blows. We must remember that speech is an important control device (just as it is a display device). The locomotive engineer receives information from the despatcher and in turn may give information or instruction to the trainman, leading to a change in the state of the system.

Interface de commande

Le deuxième élément du modèle présenté est le moyen par lequel l'opérateur modifie l'état du système. Tout se passe comme dans le cas précédent, sauf que l'information circule de l'opérateur vers le système, amenant celui-ci à emprunter un nouvel état parmi tous les états possibles. Maintenir le système dans son état existant, c'est à dire ne rien y changer, constitue, il ne faut pas l'oublier, l'un de ces états. La voie empruntée pour cet échange est celle de l'interface de commande (figure 5).

Encore une fois, nous pouvons énumérer et évaluer tous les dispositifs de commande prévus à cette fin : manettes, boutons, interrupteurs, robinets, etc. (figure 8). Comme dans le cas de l'interface de visualisation, il peut y avoir des signaux informels. On peut aisément imaginer le conducteur d'une locomotive à vapeur modifiant l'état de la mécanique par quelques coups bien placés. Il ne faut pas oublier, non plus, les messages verbaux qui sont, eux aussi, un moyen important de commande, tout autant qu'ils sont une source d'information. En effet, le conducteur reçoit de l'information de l'agent de régulation et, à son tour, la transmet au garde-frein, le tout en vue d'amener un changement dans le système du train.

HOW GOOD IS THE CONTROL INTERFACE
QUALITÉ DE L'INTERFACE DE COMMANDE

- What actions does the operator take in performing the task?
- Quelles sont les opérations effectuées par l'opérateur pour accomplir une tâche donnée?

- What devices are used in making those actions?
- Quels sont les dispositifs utilisés à cette fin?

- Can the devices be operated in a safe and efficient manner?
- Est-ce que ces dispositifs peuvent être manoeuvrés de façon sécuritaire et efficace?

- Are there actions which the operator should be able to take which are not available to him or her?
- Existe-t-il des opérations que l'opérateur devrait pouvoir effectuer alors qu'il ne le peut pas?

- How does the operator know that he or she has made the action intended and with the intended effect?
- Comment l'opérateur peut-il déterminer s'il a effectué l'opération voulue et que celle-ci a donné le résultat souhaité?

Figure 8
Evaluating the control interface

Figure 8
Évaluation de l'interface de commande

Looking at the control interface as a whole, we can make two general observations. First, for each device operators must be able to make the bodily movements its use demands. This raises questions like strength requirements (both static and dynamic), and accessibility and posture. Operators must be able to get at the device and must be able to maintain the posture required for getting at the device (figure 9).

En ce qui concerne l'interface de commande, deux remarques générales s'imposent. D'abord, à chaque dispositif doit correspondre un geste que l'opérateur est en mesure d'exécuter. Les paramètres corollaires sont, entre autres, la charge musculaire tant dynamique que statique, la charge posturale et l'accessibilité. En effet, non seulement l'opérateur doit-il pouvoir atteindre la commande, mais aussi maintenir la posture qui lui est imposée (figure 9).

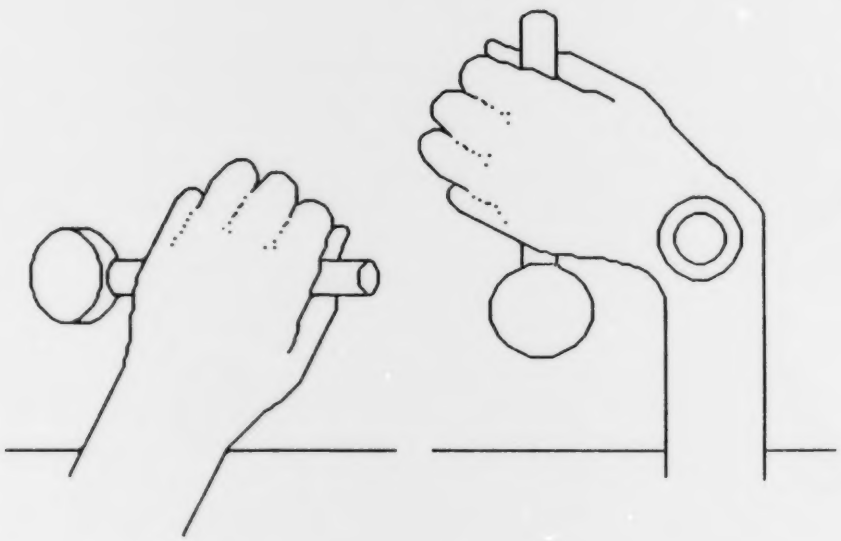
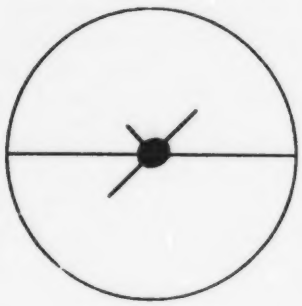


Figure 9
Operators must maintain appropriate postures and should not be required to maintain clumsy or fatiguing postures. For example, control levers should not be mounted as if the operator's hand were pivoted at the wrist.

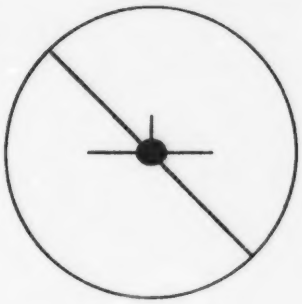
Figure 9
La charge posturale ne doit pas exiger des manoeuvres difficiles ou fatigantes. Exemple : une manette ne doit pas être placée comme si la main de l'opérateur pouvait pivoter latéralement.

Secondly we must take account of the relationship between control actions and system effects, and whether they match expectations. Some expectations are so well developed as to form stereotypes, and if operators are required to act contrary to those expectations, the probability of error increases (figure 10).

Ensuite, il faut prendre en compte la relation entre l'activité de commande et l'effet produit, puis vérifier si la réponse correspond à ce qui est attendu, c'est-à-dire aux exigences perceptives Certaines de ces exigences sont ancrées en nous au point de devenir des stéréotypes. Lorsque l'opérateur est forcé d'agir contrairement à ceux-ci, les risques d'erreur augmentent (figure 10).



A



B

Figure 10
Most operators using instrument A want to turn the control device to the right (or clockwise) to bring the controlled element (the aircraft symbol) into line with the horizon but many using instrument B want to turn it to the left. Both instruments, in this example, are displaying the same information and require the same response.

Figure 10
Si on demande à des opérateurs de mettre l'élément commandé (ici, le schéma d'un avion) parallèle à l'horizon, la plupart voudront tourner la commande du dispositif A dans le sens des aiguilles d'une montre, tandis que, sur le dispositif B, ils voudront la tourner dans le sens contraire (vers la gauche). Les deux dispositifs de cet exemple affichent la même information et demandent la même réponse.

In considering the design of the control interface we must take account of feedback (see figure 5). While the control interface is the channel for giving information to the system, it is also, from the operators' point of view, part of the display interface. As such, they use it to know that the control device has been manipulated, that it has been manipulated in the way intended, and that the manipulation has had the intended effect on the system.

Dans l'étude de l'interface de commande, la rétroaction doit être prise en compte (voir figure 5). En plus d'être le moyen par lequel l'information est transmise au système, cet interface fait aussi, du point de vue de l'opérateur, partie de l'interface de visualisation. À ce titre, l'opérateur s'en sert pour savoir si une commande a été transmise et, dans ce cas, si elle l'a été de la manière voulue et surtout si elle a eu l'effet désiré sur le système.

When we switch on the room light we can see and feel (and perhaps hear) the toggle to know that the switch has been thrown and thrown in the way intended, and the light's coming on shows that we have had the intended effect. Not all devices give this information. For example, some push-button switches assume the same aspect whichever mode they are in, supplying in effect no direct feedback. The problem can be resolved by having the switch operate a binary indicator, illuminated, say, for one switch mode and extinguished for the other. This is an improvement but it still gives no feedback concerning the actual state of the device being controlled. One of the problems encountered in the Three Mile Island incident was that the operators thought they had an indication of the state of certain valves, whereas they actually had indication of the state of the devices controlling those valves. Unfortunately the devices were not functioning correctly, and so the feedback they were receiving was not only inadequate but also misleading.

Design of workplace is a topic which is obvious enough but not necessarily for that reason adequately addressed, although it is thoroughly worked over by textbooks in ergonomics.

Decision-making

Having considered two of the elements in our model, we now consider the element lying between them, that is what goes on in the mind of the operator. The operator perceives the information provided by the display interface and responds with actions mediated through the control interface, and the aim is to produce the correct action in response to a correct perception. In this, we may say, lies the skill of the operator, and we have here, in a sense, the crux of the matter.

En entrant dans une pièce, lorsqu'on actionne l'interrupteur, on peut voir, sentir (et peut-être même entendre) la bascule agir dans le sens voulu, et la lampe qui s'allume montre que l'action a eu l'effet désiré. Mais tous les dispositifs ne donnent pas cette information. Certains boutons-poussoirs gardent le même aspect quel que soit leur état, ne fournissant aucune information directement perceptible en retour. La solution consiste à doter l'interrupteur d'un indicateur binaire qui s'allume ou qui s'éteint selon que le courant passe ou ne passe pas. C'est déjà un progrès mais il n'y a toujours pas de réaction sur l'état du dispositif commandé. L'une des causes de l'accident de Three Mile Island a été que les opérateurs croyaient avoir une indication sur l'état de certaines vannes, alors qu'en fait cette indication concernait l'état des dispositifs commandant ces vannes. Malheureusement, comme ceux-ci fonctionnaient mal, l'information perçue par les opérateurs était non seulement inadéquate mais, en plus, faussement rassurante.

Tous s'accordent à dire que l'étude ergonomique des postes de travail est indispensable mais, bien que la question ait été traitée de long en large dans les ouvrages sur l'ergonomie, on ne peut pas présumer qu'elle l'a été adéquatement.

Prise de décision

Après avoir examiné deux des éléments de notre modèle, passons maintenant à l'élément intermédiaire, à savoir l'élément humain. Celui-ci reçoit l'information affichée par l'interface de visualisation et répond en agissant sur l'interface de commande, l'objectif étant de produire une réponse correcte à une perception correcte. C'est à ce niveau qu'intervient justement l'habilité de l'opérateur, et c'est là le noeud de l'affaire.

Perception consists of more than mere sensory input, a point that can be very easily demonstrated. Figure 10 illustrates the problem of stereotypes and the effect expectations have on how operators respond, and figure 11 shows that expectations can also affect operators' perceptions of what is presented. Perception is not so much what is seen, heard or felt, but the way that what has been seen, heard or felt is interpreted, and the interpretation is affected by a number of factors which work in different ways for different persons.

La perception est plus qu'une simple représentation intellectuelle; il est facile de le démontrer. La figure 10 schématise le problème posé par les stéréotypes et l'effet que les exigences perceptives ont sur les réponses de l'opérateur. La figure 11 veut illustrer un autre effet, à savoir que les perceptions sont influencées par ce que l'on s'attend à percevoir. La perception est donc moins un effet de nos sens que la manière que nous avons d'interpréter leurs messages. Or, cette interprétation dépend d'un certain nombre de facteurs qui agissent différemment selon les personnes.

Figure 11
Many persons reading, at a glance, the message circumscribed in the triangle read it incorrectly. Curiously enough, they are not able to say, when they note their mistake, which of the two repeated words was the one they had not seen.

Figure 11
La plupart de ceux qui jettent un coup d'oeil rapide sur le message inscrit dans le triangle font une erreur de lecture. Fait curieux, ils ne peuvent, une fois qu'ils s'en sont rendus compte, dire lequel des deux mots répétés était celui qu'ils n'ont pas vu.

Operators' abilities to interpret information relevant to the task, and from it to select correct responses, derive from what they have learnt during a process of explicit and implicit instruction, and from experience of the job. These aspects of learned behaviour are said to reside in long-term memory, as distinct from short-term memory which deals with more transient material. Short-term memory has certain functional characteristics which affect the way operators perform the task, one of the most obvious being its limited capacity. In general terms, a person can handle about seven items of information at a time. Errors become more frequent if this limit is exceeded. The telephone code is an example of a well-designed code in that it uses seven digits. If it had, say, twelve digits we would have greater difficulty holding a telephone number in short-term memory while we dial (figure 12).

L'habilité de l'opérateur à interpréter l'information pertinente à la tâche qu'il doit exécuter, et à organiser la réponse appropriée découle de son apprentissage tant explicite qu'implicite et de son expérience antérieure. Ce sont deux caractéristiques du comportement acquis que l'on dit propres à la mémoire à long terme, par opposition à la mémoire à court terme qui ne retient que des informations ponctuelles. Une des caractéristiques fonctionnelles de cette dernière, et qui touche le comportement de l'opérateur face à sa tâche, est sa capacité limitée. Généralement parlant, la mémoire à court terme peut retenir jusqu'à sept éléments d'information à la fois, les oublis devenant plus fréquents, au-delà de cette limite. Un exemple intéressant de cette faculté est fourni par les numéros de téléphone qui sont formés de sept chiffres. Un numéro plus long, disons de 12 chiffres, aurait été plus difficile à retenir dans notre mémoire à court terme qui sert pendant que nous composons (figure 12).

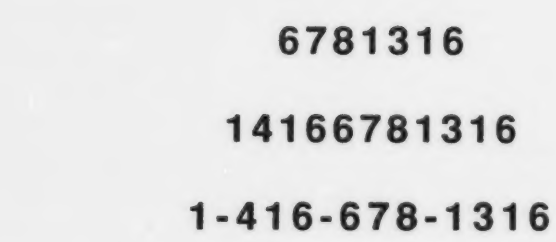


Figure 12
Seven digits can be held readily in short-term memory, but eleven digits are more difficult. The difficulty can sometimes be alleviated by "chunking" the material, and by giving the chunks an external (say, geographical) reference.

Figure 12
Il est plus aisé de retenir dans sa mémoire à court terme un numéro composé de sept chiffres qu'un numéro formé de onze chiffres ou plus. On peut contourner cette difficulté en découpant le numéro et en donnant à chacun des "morceaux" une signification particulière, géographique, par exemple.

Another component falling in this area of our model is that of attention. Human operators are best thought of as single-channel processors, able to attend to only one thing at a time. They can switch channels very rapidly, and this may lead to the impression that an operator can deal with more than one thing at once, but that can only be taken so far, and we should avoid overloading operators beyond the limit.

Conversely there is a problem of underloading. Operators with too little to do may lapse into inattentiveness, and fail to handle even what little is required of them. This is recognized in railway operation where vigilance devices (deadman pedals in the Canadian context) are installed to monitor attentiveness, although the effectiveness with which these devices work is itself a problem of ergonomics.

All of these elements relate to the operator as a decision maker: interpreting incoming signals, analyzing the result in the light of task requirements, and selecting appropriate responses. Human operators are well designed for carrying out these kinds of functions, so much so that they cannot readily reflect upon them or articulate what it is they are doing, and observers believe that not very much is really going on. Nothing could be further from the truth, and it is the task of the ergonomist to make this process apparent and to specify the factors that affect it.

Un autre élément de notre modèle est le niveau d'attention de l'opérateur. Celui-ci s'apparente à un processeur monovoie. Il ne peut accorder son attention qu'à une seule chose à la fois; cependant, comme il peut passer très rapidement d'une voie à une autre, on a l'impression qu'il peut détecter plus d'un stimulus à la fois. Mais il faut surtout éviter d'imposer à l'opérateur une charge mentale supérieure à ses possibilités car cela pourrait causer des problèmes.

À l'inverse, il y a la situation de faible charge, durant laquelle l'opérateur risque de tomber dans l'inattention, au point même de ne plus pouvoir faire le peu qu'on lui demande. Pour obvier à ce danger, les sociétés ferroviaires ont fait installer des dispositifs (au Canada, ce sont les pédales de sécurité) dans le but d'empêcher les conséquences graves d'un manque de vigilance de la part de l'opérateur. Quant à l'efficacité de ces dispositifs, c'est une autre question relevant de l'ergonomie.

Tous ces éléments sont liés à l'opérateur dans son rôle d'agent de décision : interprétation des signaux reçus; traitement de l'information reçue à la lumière des consignes; formulation de la réponse appropriée. Ce sont là des fonctions que l'être humain peut aisément accomplir, sans nécessairement pouvoir les décrire verbalement ni les expliquer de façon rationnelle. Un observateur peu averti ira jusqu'à dire qu'il ne se passe rien. Mais c'est une erreur! Il appartient à l'ergonomiste de mettre en évidence ce processus intérieur et de déterminer les facteurs pouvant l'influencer.

Indirect Factors

We have considered the three elements in our model that relate directly to the operator, and we now turn to three other elements which have an indirect effect on operators and the way they perform the task (figure 13). The first of these, the training and experience of the operator, does not need much comment at the moment. Clearly, the operator has to learn the skills necessary to perform the task. There are various techniques for imparting this information, some of which are more effective than others. An additional problem in this area relates to the need for maintaining and updating skills as new devices and equipment are incorporated into the system.

Facteurs indirects

Après avoir considéré les trois éléments de notre modèle qui sont directement reliés à l'opérateur, passons maintenant à trois autres dont l'effet sur l'opérateur et sur son travail est indirect (figure 13). Le premier de ces trois éléments : apprentissage et expérience de l'opérateur, n'a pas besoin d'être longuement explicité ici. Il est évident que l'opérateur doit apprendre son métier; pour cela, il y a diverses méthodes d'efficacité variable. Il y a aussi le problème de l'actualisation des connaissances et des aptitudes, à mesure que le système sur lequel il agit est modernisé ou amélioré.

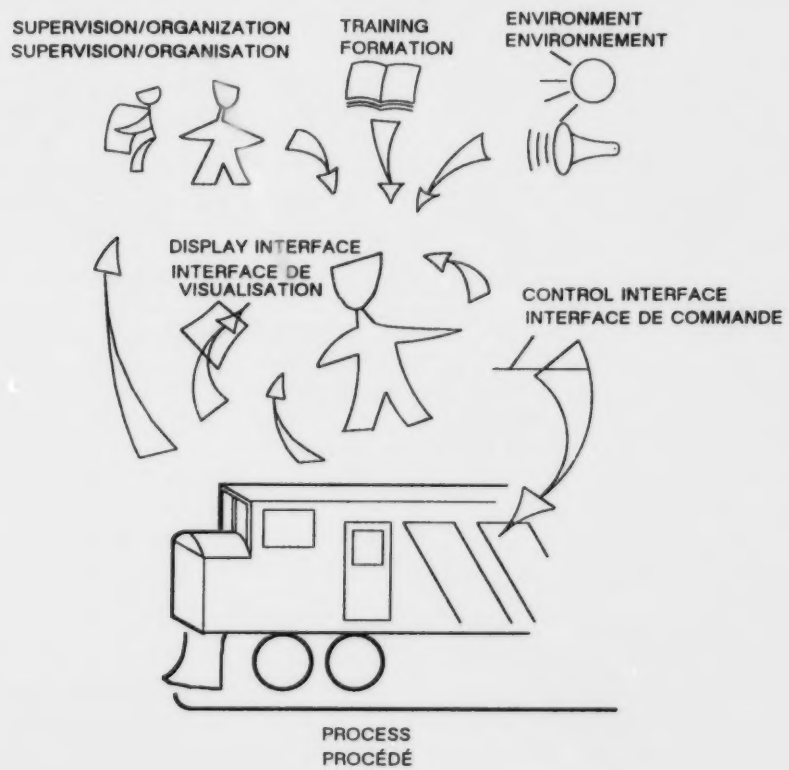


Figure 13
In addition to the direct factors relating to the display and control interfaces, and to the internalised decision-making processes, the performance of the operator is affected by indirect factors, notably training, environmental conditions, and social and organizational conditions.

Figure 13
Outre les facteurs directs reliés aux interfaces de visualisation et de commande et aux divers mécanismes entrant dans la prise de décision, il existe aussi des facteurs indirects qui peuvent influencer le comportement de l'opérateur : apprentissage, milieux ambiants et climat socio-technique.

The second element encompasses the physical environment in which the operator performs the task. This includes questions of lighting, noise, heat, humidity, vibration, air quality and so on. Many studies have demonstrated the deleterious effects on performance that can arise from poor control of these factors, although setting appropriate levels is not necessarily a simple matter. Lighting, for example, must be sufficient to enable operators to see what they have to see without suffering from glare or excessive levels of illumination. Again, in looking at vibration we must remember that vibration may be a source of useful information, as well as serving to maintain attentiveness, so that what constitutes the best level of vibration is not always easy to decide.

Le deuxième élément est l'environnement physique dans lequel évolue l'opérateur : éclairage, bruit, chaleur, humidité, vibrations, qualité de l'air, etc. L'effet de tous ces facteurs sur la salubrité et l'efficacité du travail a été amplement démontré, bien que leur régulation soit loin d'être simple. Par exemple, l'éclairage doit être suffisant sans être excessif. De même, les vibrations peuvent apporter une information utile, en plus de stimuler la vigilance. Mais à quel niveau fixer l'effet vibratoire optimal? Voilà qui n'est pas facile à déterminer.

The one thing we need to avoid in this respect is the view that we are somehow mollycoddling operators if we attend to these questions. When we install computers in our workplaces, every consideration is given to matters of air-conditioning and the like because we know that there are limits outside of which computers will not function properly. We should not find it odd that there are such limits for human operators, and we should not be shy about observing them.

Ce qu'il faut surtout éviter de croire, c'est que, avec toutes ces préoccupations, on cherche à ménager les opérateurs. Ridicule! Lorsqu'une entreprise fait installer un ordinateur, ne lui affecte-t-elle pas un endroit approprié et climatisé hors duquel l'ordinateur ne saurait fonctionner convenablement? De même, il ne faudrait pas s'étonner qu'il y ait des limites à la capacité humaine, que l'on aurait tort de ne pas prendre au sérieux.

The third element encompasses the social and organizational environment. No task is performed without some reference to another person: either a fellow operator, a supervisor, or a colleague having an interacting function. For a locomotive engineer, these include the trainman and conductor, the yard foreman and the despatcher. The fact that they are there implies the need for procedures, methods and techniques of communication designed to facilitate accurate exchange of information. These factors affect performance both directly and indirectly in more subtle ways relating to personal goals and self-esteem.

Le troisième élément est constitué par les interactions sociales et organisationnelles. Il n'y a pas de tâche qui s'exécute totalement en vase clos : il y a toujours un collègue à avertir, un surveillant à consulter, une fonction connexe à prendre en compte. Dans le cas du conducteur de locomotive, cela inclut le garde-frein, le chef de train, le contremaître de triage et l'agent de régulation. Leur présence implique la nécessité de procédures, méthodes, techniques de communications destinées à assurer un échange d'information libre et exempt d'erreurs. Ces facteurs exercent une influence directe et indirecte sur l'opérateur de façon si subtile qu'ils finissent par constituer une charge affective.

Alongside these purely social factors are those relating to the way work is organized, including factors like the assignment of responsibility and the scheduling of hours of work and rest periods. Studies of hours of work were among the earliest investigations carried out when it was first conceded that operators were human and needed to be treated accordingly. What we need to do now is to apply the results of those studies.

Conclusion

In concluding this review of the information-processing model of operator function, I want to make three more general points about the model and about the approach that its use implies.

First, the model provides a rational and coherent basis for handling questions which can otherwise be elusive and frustrating. We know that human operators are there somewhere in the system, and we know that somehow or other their presence has to be taken into account. The problem has been how to do it.

Often that problem has been solved by default. The attitude has been that we have managed in the past and that we shall manage equally well in the future — and in any case you only have to be human to know all about human factors. Worse still, the problem has been solved by passing it off onto the operator: either we ask the operators to tell us what they want and then, by providing it, relieve ourselves of the responsibility for the choice, or we take the attitude that it is their problem anyway and not that of the manager or the engineer or the designer.

Neither of these solutions is any longer defensible, and certainly not necessary. Ergonomics, together with the information-processing approach we have examined, provide a method for tackling the problem. It does not, without some hard work, provide an immediate answer. Rome was not built in a day and neither was the Canadian Pacific

Parallèlement à ces facteurs de type social, il y a d'autres facteurs touchant l'organisation du travail : répartition des tâches, horaires de travail, périodes de repos, etc. La question des horaires de travail a d'ailleurs été l'une des premières à faire l'objet de recherches lorsqu'il a été finalement admis que les opérateurs étaient après tout des humains et qu'il fallait les traiter comme tels. Ce qu'il reste à faire, c'est utiliser les résultats de ces recherches.

Conclusion

Avant d'en finir avec notre modèle du fonctionnement de l'opérateur axé sur le traitement de l'information, je voudrais faire trois autres remarques générales à son sujet en ce qui concerne son application.

Premièrement, il constitue un moyen rationnel et cohérent d'envisager des questions qui, autrement, nous apparaîtraient insaisissables et frustrantes. Nous savons que l'élément humain fait partie du système et que sa présence doit, d'une façon ou d'une autre, être prise en compte. Le problème est de savoir comment.

Souvent, la solution adoptée était de laisser faire et de se cantonner derrière des raisonnements comme ceux-ci : "Nous nous sommes bien débrouillés jusqu'ici et nous nous débrouillerons aussi bien demain" et "De toutes façons il suffit d'être un humain pour connaître les facteurs humains." Pis encore, nous nous en sommes tirés en demandant à l'opérateur ce qu'il veut et en le lui fournissant une fois pour toutes, ou bien nous nous sommes dits que c'était son problème, et non celui de l'ingénieur ou du concepteur.

Aucune de ces solutions n'est encore admissible de nos jours, ni même utile, puisque nous disposons désormais de l'ergonomie et du modèle du fonctionnement de l'opérateur que nous avons présenté ici. Les réponses fournies ne seront jamais simples, ni rapides, mais rien de bon ne se fait sans effort. Et, après tout, nous n'allons pas

Railway, and nor are we going to solve in a day all the problems of integrating operators efficiently and safely into our systems new and old. But we do now have a method.

Secondly, this approach not only gives us a method of tackling the problem: it also gives us a method of bringing to bear the expertise needed to solve it. We are not dealing here with simple questions. Knowing how to do a task is a long way from knowing how it is done. We all know how to write our names but how many of us know how knowledge of our name is stored somewhere in our brain, how that stored knowledge is accessed when we need it, how the commands necessary to convert that knowledge into hand movements are produced, how in converting that knowledge we take account of the characteristics of the writing instrument we are about to use or the surface we are about to write on, or how we know that we have done what we set out to do.

These are far from simple questions, but similar questions could be framed about all of the matters raised in this paper. The so-called experts do not know all of the answers, but at least expertise should be recognised where it does already exist.

Thirdly, this approach is superior to its alternatives, being based on empiricism and good theory. Too many decisions about the operator and his work are made on the basis of opinion and conjecture. Now opinion may in fact be well-founded, and indeed the conjectures may be correct, but if they are, then it should be possible to subject them to the test of empirical verification.

As for theory, I referred at the beginning of this talk to the fact that other models were used before the information processing model as a basis for understanding operator behaviour. What I had most in mind was the one known as the stimulus-response model, based on theories of conditioning. I mention it because it continues to influence thinking about these matters even though it is discredited among ergonomists.

trouver du jour au lendemain une solution à tous les problèmes d'ergonomie, passés ou actuels. Mais du moins la méthode est là, à nous de l'utiliser.

Deuxièmement, ce modèle nous montre comment nous y prendre pour aborder le problème à l'étude et faire intervenir les compétences nécessaires à sa solution. Les questions soulevées ne sont pas simples. En effet, on peut fort bien exécuter une tâche donnée sans nécessairement savoir comment on s'y prend. Nous savons tous écrire notre nom, mais combien d'entre nous savent comment notre mémoire retient notre nom et le restitue, par quel mécanisme cette connaissance est convertie en mouvements mécaniques de notre main et, ce faisant, comment nous tenons compte de l'instrument qui sert à écrire ainsi que du type de support sur lequel nous écrivons ou, enfin, si ce qui est fait correspond bien à ce que nous voulions faire?

Ce ne sont pas des questions simples, comme d'ailleurs toutes les autres questions abordées ici. Il est vrai que nos soi-disant experts ne peuvent pas tout connaître, mais au moins reconnaissons leur savoir-faire lorsqu'il existe déjà.

Troisièmement, cette méthode est la meilleure de toutes étant donné qu'elle est fondée sur l'empirisme et sur des principes vérifiés, par opposition à nombre de décisions fondées jusqu'ici sur des idées reçues ou de simples hypothèses. Il est possible que ces idées reçues soient valides et que les hypothèses retenues soient fondées. Dans ce cas, pourquoi ne pas les soumettre à l'épreuve de la validation empirique?

Quant à l'optique théorique que j'ai évoquée plus tôt, je faisais allusion aux autres modèles dont on se servait avant l'apparition du modèle de traitement de l'information pour décrire le comportement de l'opérateur. Je pensais notamment au modèle dit de stimulus-réponse fondé sur les lois générales du conditionnement. Si j'en parle aujourd'hui, c'est parce que cette conception continue encore d'exercer une influence, même si elle a beaucoup perdu de son crédit.

Conditioning theory takes the view that learning consists of establishing links between, on the one hand, a set of signals, and, on the other, a set of possible responses. From this point of view the aim of the engineer designing a task is simply to establish the appropriate links. The continuing influence of this approach can be seen in the reliance often put upon rules and procedures, with the rule playing the role of the conditioning agent. According to this view, once the rule or procedure is established appropriate behaviour can be assumed to follow. The fact is, however, that operators do not behave like that. There is ample evidence that individuals cannot be conditioned to respond as directed, and assuming that they can leads only to trouble. This is why ergonomists have abandoned that approach, and why engineers should take care not to fall into it.

Finally, I re-iterate my first point, that ergonomics is indispensible because all artificial systems have human operators. Some people hold to the mistaken idea that automation and new technologies will eliminate operators and so resolve the problems that they bring with them. The truth is that such techniques merely re-structure the problems without eliminating them. New developments in artificial intelligence, like robotics and knowledge-based expert systems, will bring about great changes in the nature of work and the way in which people perform their tasks, but someone will have to set up and service the robot, and someone will be programming and consulting the expert system. If these devices are to work safely and efficiently the same kinds of questions about the human operator will have to be asked, even if the answers may take different forms.

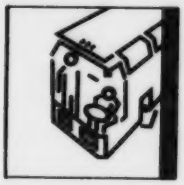
Le concept du conditionnement part de l'idée que l'apprentissage consiste à établir des liens entre, d'une part, un ensemble de stimuli et, d'autre part, un ensemble de réactions possibles à ces stimuli. Dans cette optique, la tâche de l'ingénieur concepteur de tâches sera justement d'établir les liens appropriés. Une des méthodes suivies a été celle d'instituer des procédures et règlements qui serviraient d'agent de conditionnement. D'après les adeptes de cette conception, qui n'est pas tout à fait disparue, une fois la règle ou la procédure établie, le comportement approprié suivra. Mais, en réalité, les choses ne se passent pas comme cela. La preuve a été abondamment faite qu'on ne peut pas conditionner les opérateurs pour qu'ils fonctionnent comme il leur est indiqué, et affirmer le contraire ne peut mener qu'à des déboires. C'est cette constatation qui a détourné les ergonomistes de cette approche et qui devrait inciter les ingénieurs à en faire autant.

Pour terminer, je reviens à mon argument de départ, à savoir que l'ergonomie est une discipline indispensable puisque, dans tous les systèmes artificiels, il y a des opérateurs humains qui interviennent. D'aucuns pensent à tort que l'automatisation conjugée à la technologie finira par éliminer les opérateurs humains et mettra un terme aux problèmes que leur présence soulève. En vérité, ces nouvelles techniques ne font que renverser l'ordre des problèmes sans les résoudre. L'intelligence artificielle, les robots et les systèmes experts bouleverseront sans doute les méthodes de travail et le fonctionnement des opérateurs, mais il faudra toujours quelqu'un pour monter le robot et l'entretenir, quelqu'un pour programmer le système expert et quelqu'un pour l'interroger. Afin que toutes ces techniques puissent fonctionner sûrement et efficacement, les mêmes questions qui se sont posées à propos de l'opérateur humain devront être de nouveau posées, même si l'on peut s'attendre que les réponses à ces questions empruntent de nouvelles formes.

The value and validity of the ergonomics approach has already been demonstrated in numerous fields, and we expect its range of application to increase. The speakers in this seminar show how this is happening in the field of transportation. At the same time we realise that the approach is not fully understood and that practical difficulties continue to arise. We want to solve those problems and we hope therefore that the symposium will be a truly interactive information processing event.

Après avoir fait ses preuves dans de nombreux domaines, voilà maintenant que l'approche ergonomique commence à trouver de nouveaux champs d'application. Les participants à ce séminaire l'ont d'ailleurs bel et bien démontré en ce qui concerne les transports. Mais il faut admettre que l'approche ergonomique n'est pas encore tout à fait au point, à preuve les écueils d'ordre pratique auxquels elle se heurte encore. Nous comptons sur ce colloque et sur les échanges d'idées qu'il pourra susciter pour arriver enfin au but que nous nous sommes fixé.

WORKSHOP 1
HUMAN/VEHICLE INTERACTION

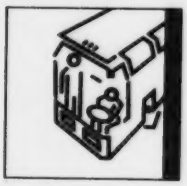


Fitting Persons and Vehicles Together

Chairperson — D. Lewis,
James F. Hickling Management Consultants Ltd.

Dr. Lewis recently obtained a Ph.D. in economics. He has undertaken numerous projects in the area of transportation. He was Program Co-ordinator for the Fourth International Conference on Mobility and Transport for the Elderly and Disabled in Vancouver in 1986 and is on the Board of Editors of the international journal "Specialized Transportation Planning and Practice".

ATELIER 1
INTERACTIONS HOMME-VÉHICULE



L'adaptation des véhicules aux besoins de l'homme

Président — D. Lewis,
James F. Hickling Management Consultants Ltd.

Titulaire depuis peu d'un doctorat en économie, D. Lewis a à son actif de nombreux projets de recherche en transports. Il a été coordonnateur de programmes à l'occasion de la IV Conférence internationale sur la mobilité et le transport des handicapés tenue à Vancouver en 1986, et est membre du comité de rédaction de la revue internationale "Specialized Transportation Planning and Practice".

Élaboration d'un dispositif (miroir) pour assurer la vigilance de départ au métro de Montréal

R. Gilbert, Ph.D.

Doctorat en physiologie en 1970.

Fondateur et directeur du laboratoire d'ergonomie de l'École Polytechnique.

Professeur agrégé au département de Génie industriel de l'École Polytechnique.

Il a publié plusieurs travaux et donné plusieurs conférences en ergonomie Santé et sécurité au travail, notamment dans le domaine du transport :

1. *Étude des problèmes de vision et d'éclairage du centre de contrôle du métro de Montréal.*
2. *Réaménagement complet du poste de conduite du métro.*
3. *Étude rétrospective et prospective des problèmes reliés à la conduite des véhicules lourds.*
4. *Étude de la causalité des accidents dans le domaine du transport.*

Est responsable du certificat en technologie de la prévention des accidents à l'École Polytechnique.

Agit régulièrement comme expert auprès de divers organismes en Santé et sécurité au travail.

Examinateur pour l'Ordre des Ingénieurs.

Membres de plusieurs associations.

Membre de plusieurs comités dont le comité associé du CNRC pour l'application industrielle de l'ergonomie.

Directeur de la division ergonomie chez Genicom Inc.

Introduction

Dans le métro de Montréal, la vigilance du quai avant le départ était assurée par l'opérateur en regardant par la fenêtre latérale la tête légèrement sortie. L'agent d'accompagnement faisait de même. Suite à un accident mortel survenu en tunnel où un agent d'accompagnement s'était sorti la tête et le tronc, la CSST imposa des scellés sur les fenêtres latérales. Une étude préliminaire permit d'exclure les systèmes de caméra ainsi que tout dispositif installé sur les trains. Ainsi, il restait l'option d'un miroir dont l'étude rapportée ici fut réalisée en 1982-1983.

Problématique

Sachant à l'avance que la hauteur des yeux varie selon les opérateurs et sachant également que les trains ne s'immobilisent pas exactement au même endroit et ayant comme contrainte un miroir fixe installé à demeure, cela exclut d'emblée le miroir plan. Compte tenu également des contraintes de coût, il faudra se satisfaire d'un miroir disponible sur le marché. Essentiellement, on retrouve deux types de miroirs convexes, l'un sphérique et l'autre à surface toroïdale. Compte tenu de l'espace restreint, des rayons de courbures disponibles et de l'architecture des stations de métro, nous avons choisi le type à surface toroïdale déjà taillé en rectangle. L'étude proprement dite consiste à choisir une surface toroïdale convenable, à déterminer son emplacement et son orientation.

CHOIX DE LA SURFACE TOROÏDALE

Une étude préliminaire nous a permis d'établir l'ordre de grandeur de la plage couvrant la position possible des yeux dans l'espace. Il s'agit d'une plage se situant à toute fin pratique dans

un plan où l'étendue horizontale est d'environ 1 mètre et l'étendue verticale d'environ 30 cm. Compte tenu des contraintes sur l'emplacement éventuel du miroir, nous pouvons calculer qu'un des miroirs disponibles sur le marché ayant des rayons de courbure r, et r_2 (figure 1) respectivement de 195 cm et 170 cm admet une plage pour r^2 d'environ 1,5 mètre comparativement à une plage estimée d'environ 1 mètre. Dans l'autre plan, la plage disponible avec r, déborde largement nos exigences. Comme nous désirons le minimum de déformation, le miroir en question constitue notre meilleur choix à la condition qu'il satisfasse les exigences visuelles de la tâche.

EXIGENCES VISUELLES

Auparavant, les exigences visuelles consistaient essentiellement à s'assurer que l'opérateur et l'agent d'accompagnement puissent voir toute anomalie susceptible d'entraîner des blessures aux usagers lors du départ après la fermeture des portes jusqu'à ce que le train ait complètement quitté la station.

Même si les portes sont munies de détecteurs de fermeture, il reste qu'un vêtement coincé ainsi qu'une main ou un poignet peuvent ne pas être détectés par le dispositif, c'est alors que l'exploration visuelle trouve son utilité. On comptait également sur le fait que l'opérateur ou l'agent d'accompagnement puisse voir par exemple une personne chuter entre deux wagons.

Nos objectifs pour le miroir sont donc d'offrir au moins les mêmes possibilités. Cependant, il convenait d'au moins tenter de préciser la qualité d'une telle vigilance dans les faits. Pour ce faire, nous avons : 1° examiné les résultats d'une enquête menée par les exploitants du réseau sur de tels accidents en station, 2° mené une enquête auprès des opérateurs et 3° procédé à la vérification du contenu du champ visuel. En résumé, tous les accidents ainsi survenus, avaient totalement échappé à la vigilance visuelle, autrement dit, il n'est pas arrivé par exemple que l'agent d'accompagnement arrête le train en station suite à la détection d'une situation précédemment décrite. L'enquête auprès des opérateurs a donné des résultats peu utiles. En effet, pour certains, on prétendait avoir toujours détecté ces situations et procédé à l'arrêt du train du moins dans la fonction "agent d'accompagnement", alors que pour d'autres, on mentionnait des empêchements à réaliser cette vigilance ainsi que des risques tels que se faire frapper ou cracher au visage par des voyous lorsque la tête est sortie. Quant aux observations que nous avons faites, il ressort qu'en périodes creuses où les risques sont les plus faibles, il est possible de voir certaines situations de risque. Par contre en période de pointe où les risques sont les plus grands, tels qu'en témoignent les dossiers d'accidents, on peut conclure à la quasi-nullité d'une telle vigilance. En effet, l'opérateur et l'agent d'accompagnement sont à 500 pieds de distance au même niveau que les usagers, pressés les uns contre les autres et suffisamment près du train pour que colis ou vêtements touchent même les wagons et cela dans un environnement bruyant. Ce qui nous amène à douter fortement des vertus d'une telle vigilance aux heures de pointe.

On doit ajouter qu'aussitôt que le train démarre la vision est en acuité visuelle dynamique et qu'il est impossible de détecter les anomalies dont il a été question en regardant défiler les usagers à un ou deux pieds de distance de l'agent d'accompagnement.

Dans de telles circonstances nous retenons comme critères visuels : 1° voir tout le long du train à la condition que des usagers ne fassent pas obstruction. Idéalement il devrait être possible de détecter un bras à 500 pieds, 2° avoir une vue plongeante de la station en particulier aux heures de pointe, de telle sorte que les incidents inaccessibles directement par la vision ou la rétrovision, le soient indirectement par des manifestations de foule. Ainsi, nous espérons, par exemple, qu'une personne tombée entre deux wagons provoque une manifestation inhabituelle du groupe de personnes aux environs qui puisse être vue.

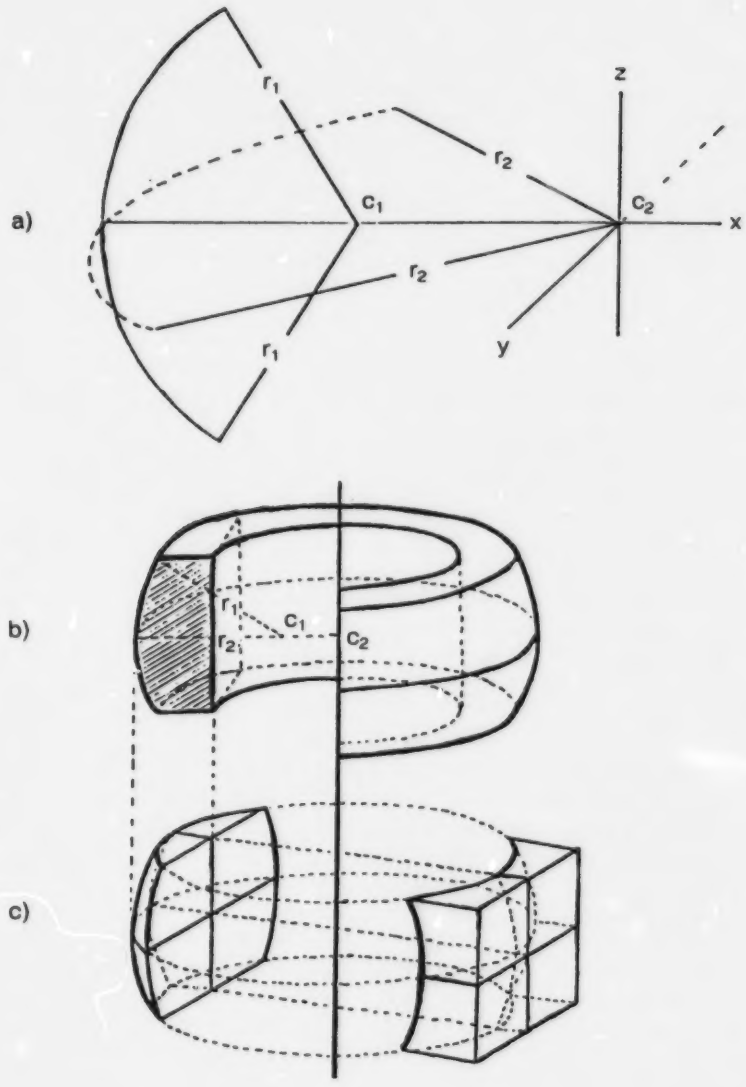


Figure 1

Mis à part les caractéristiques optiques du miroir, cela entraîne que le miroir doit être placé le plus près possible du train et assez haut. L'objectif de fixer le miroir assez haut est d'ailleurs en accord avec d'autres critères (éviter les risques de blessures aux usagers et diminuer l'accessibilité au vandalisme). Une fois les critères visuels déterminés, il faut préciser l'emplacement du miroir.

EMPLACEMENT DU MIROIR

La détermination de l'emplacement du miroir suppose dans un premier temps la détermination des positions possibles des yeux dans l'esplace et, par voie de conséquence, l'emplacement et la posture de l'opérateur. À ce sujet, nous avons d'abord fait une étude des emplacements et des postures possibles des opérateurs au moment de la fermeture des portes et au moment du départ pour les deux types de trains (MR-63 et MR-73). Dans le cas du MR-73, seule la position debout près de la fenêtre de la porte était possible alors que pour le MR-63, même la position assise dans certains cas permettait d'atteindre les commandes (fermeture des portes et départ, fig. 2). C'est ainsi que pour accommoder les deux types de trains, la position debout face à la fenêtre latérale fut retenue. Il s'agit d'une position où les yeux se retrouveront essentiellement distribués dans un plan longitudinal au train. La localisation de ce plan de même que la suite de l'étude requéraient la définition de repères. Ainsi, le portillon en bout de quai, le tympan des stations ainsi que le plancher (train et station) ont servi comme références. Le plan des yeux ayant été déterminé et situé par rapport aux repères, nous avons calculé l'étendue de la distribution des yeux sur ce dernier, compte tenu des variations dues à la population visée ainsi qu'aux variations des points d'arrêt des trains (en conduite manuelle, en pilotage automatique, pour MR-63 et MR-73 et pour un échantillon de station).

Comme le seul emplacement possible du miroir qui satisfaisait aux contraintes et aux objectifs était le tympan, nous avons procédé à l'étude de ce dernier. Dans un premier temps, nous avons créé un plan parallèle au tympan situé 6 pouces à l'avant pour tenir compte du fait que le miroir sera installé à certains angles. Ce plan parallèle au tympan nous a servi pour déterminer le meilleur compromis de localisation. En effet, nous avons réalisé une grille sur ce plan (figures 3, 4 et 5) où ont été testés les champs de vision admis par la distribution possible des yeux et les limitations de la fenêtre latérale. La figure 6 résume les résultats obtenus en supposant une fixité de positionnement des yeux pour une personne donnée. De fait, si l'on admet la variation de la rigidité posturale au gré de l'opérateur, les emplacements autorisés sont beaucoup plus grands. Si l'on cherche à voir, à ce moment toute la grille devient visible. Nous avons choisi comme emplacement optimal de situer le coin supérieur gauche du miroir à 80 pouces du sol pour respecter les contraintes de vision, les contraintes de risque de blessures et les contraintes pour minimiser le vandalisme. Une fois l'emplacement déterminé, il suffit soit de calculer les angles du miroir de façon à optimiser son positionnement dans l'espace.

POSITIONNEMENT DU MIROIR

Nous avons choisi de formuler le problème de telle sorte qu'il soit normal à la bissectrice de l'angle formé par la droite passant par la position moyenne de l'oeil et le centre du miroir et la bissectrice de l'angle formé par les deux droites bornant le champ de vision désiré. Dans ce cas, nous avantageons légèrement la partie avant du train. Pour ne pas créer un tel avantage au détriment de la partie arrière, il faudrait cibler le centre du train, ce qui équivaut à diminuer l'angle calculé d'environ 5°. Toutefois comme il arrive assez fréquemment que les trains "coulent" légèrement amenant ainsi l'oeil au voisinage du tympan de la station, il nous est apparu important de satisfaire cette situation et en conséquence de conserver ce léger "avantage" pour la partie avant du train dans la mesure où nous obtiendrons confirmation lors des tests. Il convient de souligner que nous anticipons une perte de champ d'accommodement lié à l'éventuelle nécessité technique de munir le miroir d'un cadre.

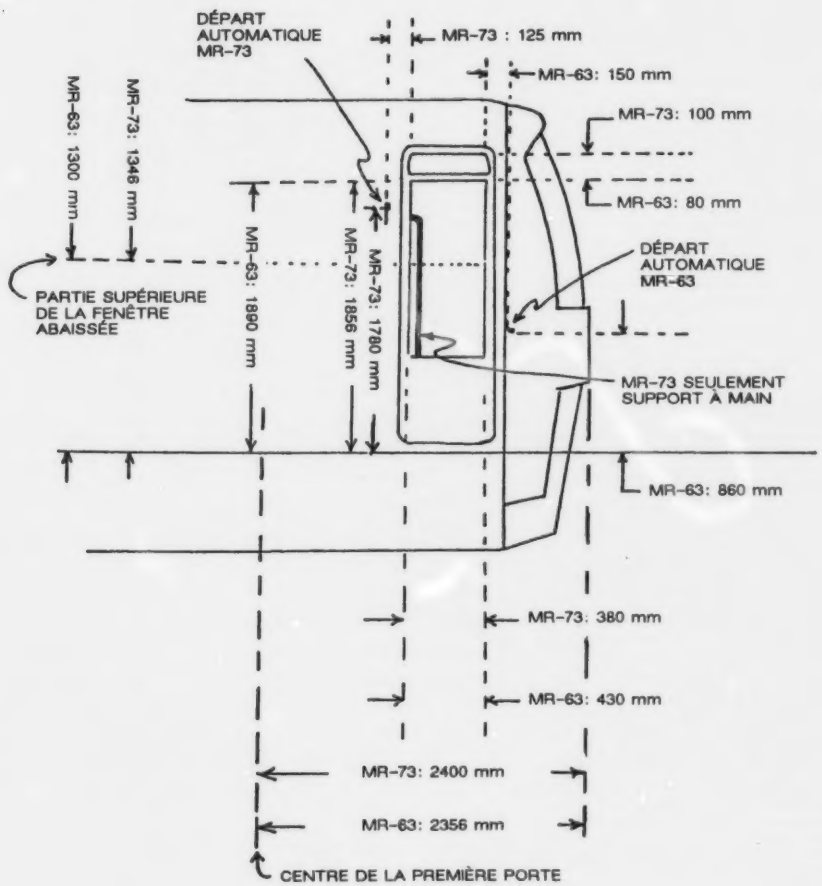
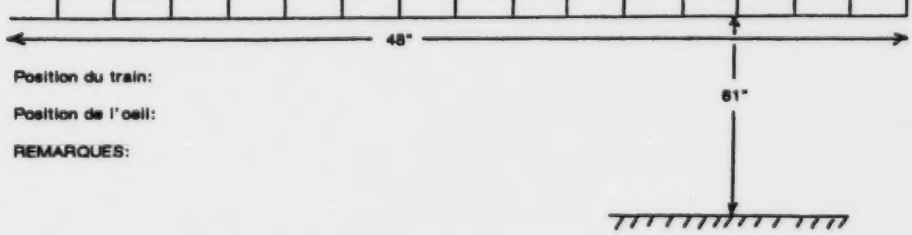

DÉPART AUTOMATIQUE MR-73
MR-73 : 125 mm
MR-63: 150 mm
MR-73: 100 mm
MR-63: 80 mm
DÉPART AUTOMATIQUE MR-63
MR-63: 1300 mm
MR-73: 1346 mm
MR-63: 1890 mm
MR-73: 1856 mm
MR-73: 1780 mm
PARTIE SUPÉRIEURE DE LA FENÊTRE ABAISSÉE
MR-73 SEULEMENT SUPPORT À MAIN
MR-63: 860 mm
MR-73: 380 mm
MR-63: 430 mm
MR-73: 2400 mm
MR-63: 2356 mm
CENTRE DE LA PREMIÈRE PORTE

Figure 2

Repérage et dimensions de la grille

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16
E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16
F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16
G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15	G16
H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16
I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16
J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16
K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16
L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16
M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16
N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	N16
O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16
P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16



Position du train:

Position de l'oeil:

REMARQUES:

Figure 3

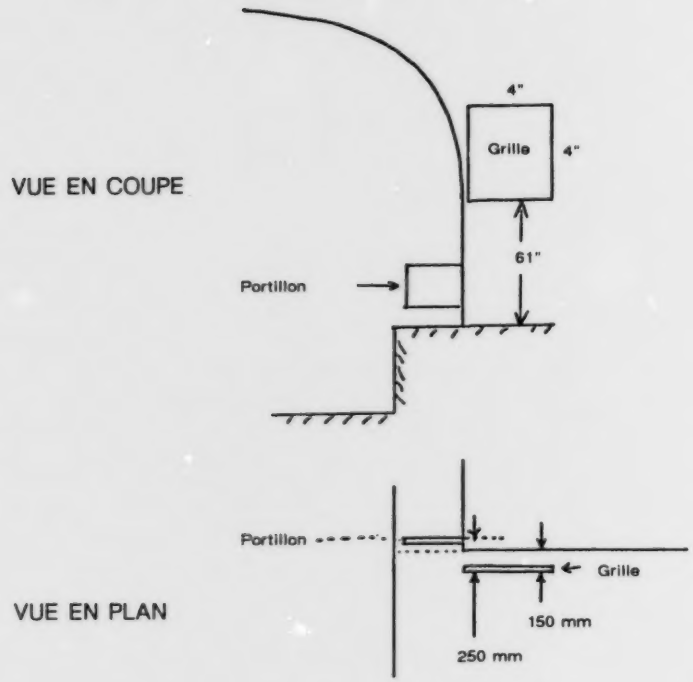

VUE EN COUPE
4"
Grille
4"
61"
Portillon
VUE EN PLAN
Portillon
Grille
150 mm
250 mm

Figure 4

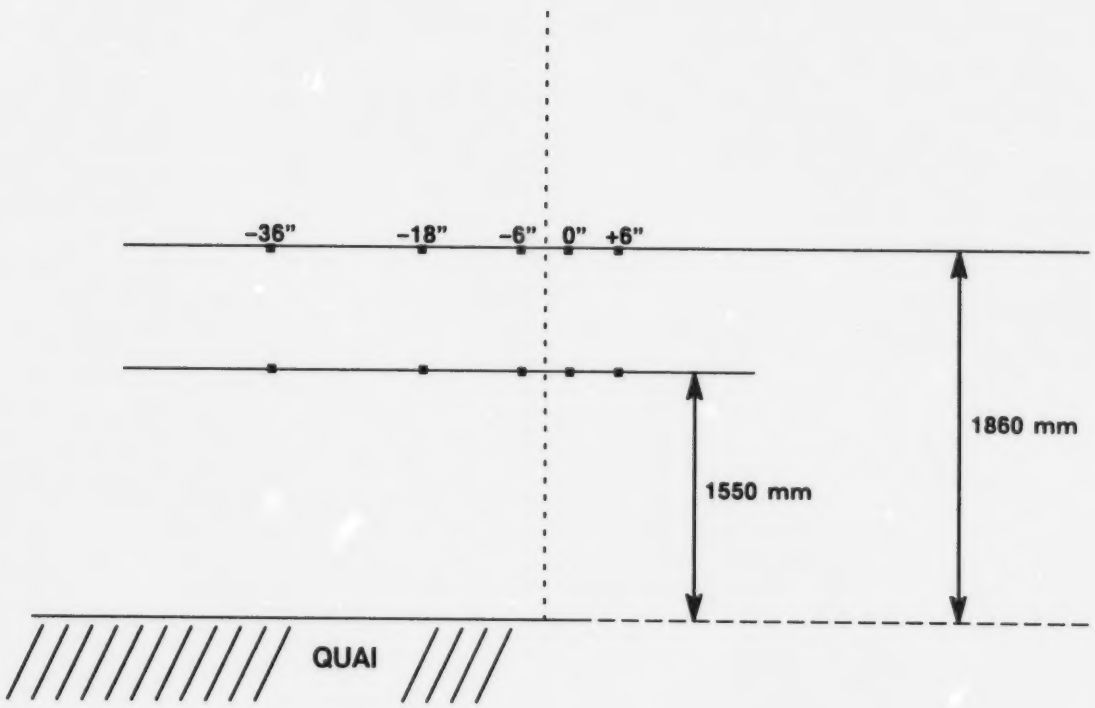
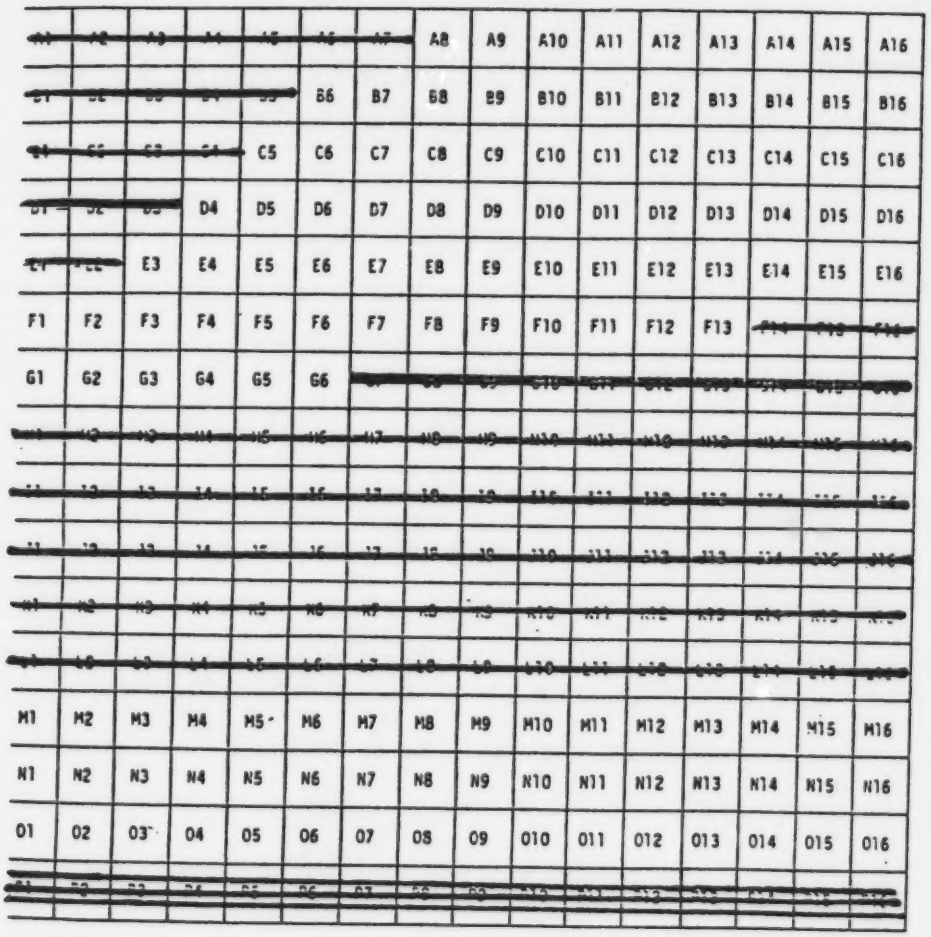


Figure 5

Situation des yeux dans un plan vertical pour la
réalisation des tests d'emplacements possibles du miroir

Synthèse des zones de vision



REMARQUES: ZONE NON VISIBLE POUR UNE PERSONNE DE 6'3"

ZONE NON VISIBLE POUR UNE PERSONNE DE 5'4"

Figure 6

Deux autres contraintes seulement sont imposées au positionnement du miroir : prévision d'un espace pour le boîtier et bord gauche vertical aligné sur le bord du tympan pour des motifs architecturaux dans ce dernier cas. La figure 7 montre la construction géométrique qui permettra de calculer le premier angle soit α. Cet angle s'exprime par l'équation suivante :

$$\alpha = 45 + 1/4 \text{ arc tg } \left(\frac{32 + 10 \cos \alpha}{95} \right) - 1/2 \text{ arc tg } \left(\frac{27.2}{38.75 + 10 \cos \alpha} \right)$$

Comme il n'existe pas de solution exacte à cette équation, α est déterminée par approximations successives, le processus étant convergent. On trouve $\alpha = 35{,}7°$.

Pour l'angle β tel qu'illustré à la figure 8, nous avons l'équation suivante :

$$\beta = 1/2 \text{ arc tg } \left(\frac{13.9 + 15 \cos \beta}{54.19} \right) + 1/4 \text{ arc tg } \left(\frac{68 + 15 \cos \beta}{103.12} \right)$$

où par la même méthode, on trouve un angle de 23,2°.

Après avoir retenu un miroir de verre plutôt que flexible (meilleur rendu des images, plus résistant aux égratignures) et après l'avoir installé selon les données obtenues, nous avons procédé à une vérification systématique des plages d'accommodation. Alors qu'il accommode toutes les hauteurs d'yeux, l'étendue longitudinale est de 28,5 pouces. Compte tenu de la précision de freinage en mode manuel ou automatique, il autorise donc la vision des éléments que nous nous étions fixés comme objectifs. Globalement le miroir est jugé satisfaisant sinon supérieur à la situation qui prévalait auparavant et cela pour l'ensemble des intervenants.

RÉFÉRENCE

GILBERT, R., *Élaboration d'un dispositif d'assistance à la vision (miroir) pour assurer la sécurité des passagers au moment du départ des trains du métro de Montréal*, 106 p., 1983.

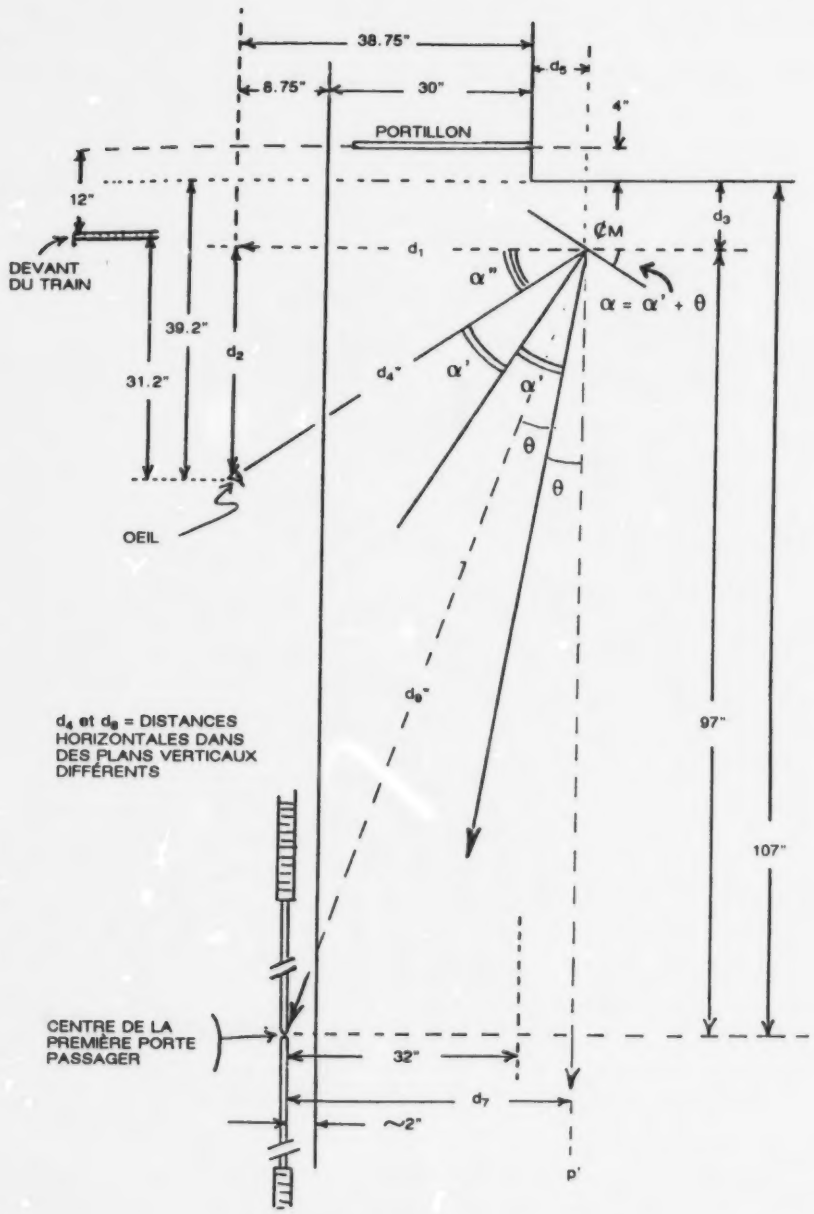
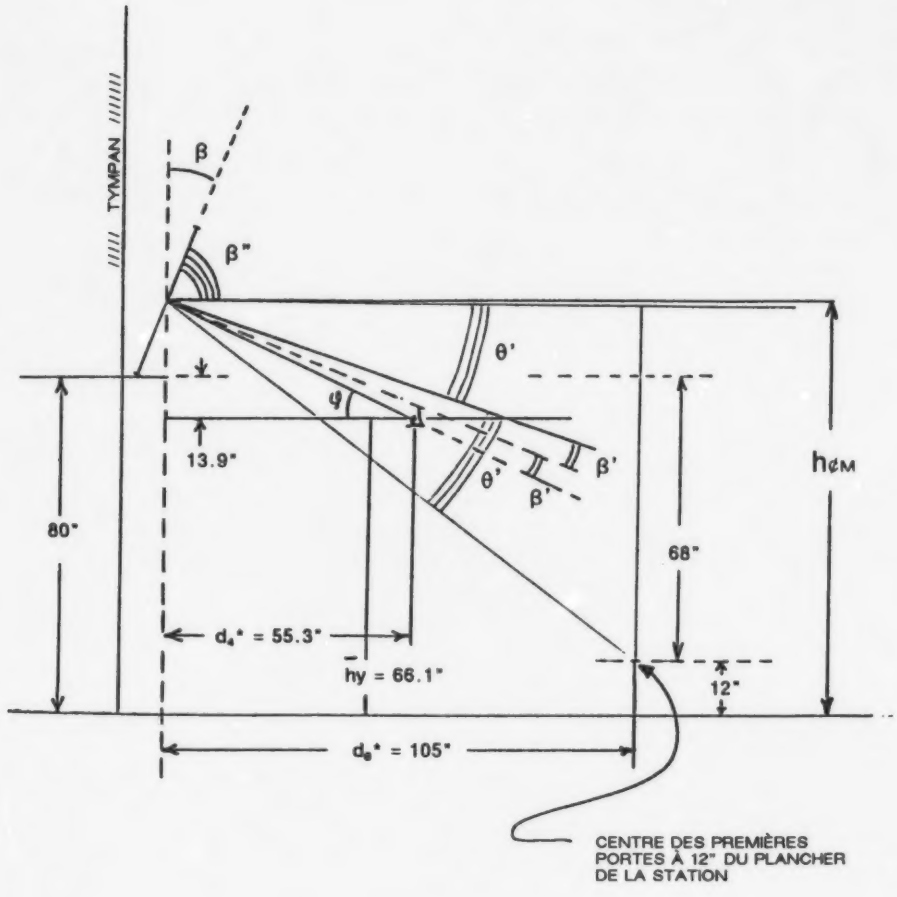

38.75"
8.75"
30"
d_5
4"
PORTILLON
12"
DEVANT
DU TRAIN
39.2"
31.2"
d_2
d_1
℄M
d_3
α''
$\alpha = \alpha' + \theta$
d_4"
α'
α'
θ
θ
OEIL
d_8"
d_4 et d_8 = DISTANCES
HORIZONTALES DANS
DES PLANS VERTICAUX
DIFFÉRENTS
97"
107"
CENTRE DE LA
PREMIÈRE PORTE
PASSAGER
32"
d_7
~2"
p'

Figure 7



* d_4 et d_9 = DISTANCES HORIZONTALES
DANS DES PLANS VERTICAUX DIFFÉRENTS

Figure 8

The Human Factors Approach and Tools in The Development of "People Movers"

F. Schneider, Humantech Incorporated

Franz Schneider is the President of Humantech Inc. and Humantech U.S.A. Inc. which are research and consulting organizations specializing in the field of human performance analysis. Franz has been active in the field of human factors engineering and health and safety for more than 10 years.

Mr. Schneider founded and organized the Ergonomics Research Group at Ontario Hydro. Prior to his work at Hydro, Mr. Schneider held a research position with the Ministry of Labour.

For the past several years Mr. Schneider has provided consultative and design services to the private sector in Canada, the United States, and Europe. Recent projects include the implementation of an ergonomics program including the analysis of over 100 workstations for several General Motors facilities, ergonomic consultation on the design of a line of new office furniture, participation in the design of a new computer system for Hewlett Packard, and consultation to Westinghouse Electric Corporation on the development of corporate strategies to improve human performance and health and safety in the workplace. Mr. Schneider's work has shown a direct impact on corporate operations performance costs in the workplace, worker performance, and organizational productivity.

One of Franz's recent projects included the review of 4,400 office workers operating in various levels of technology integration. This project included the assessment of the impact of training and office design on clerical and managerial productivity.

Mr. Schneider has two B.Sc. degrees (cum laude) from the State University of New York, in physiology and psychology, an M.Sc. in Human Biology from the University of Guelph, and a Diploma from the University of Cologne.

What is important to us today when we talk about transportation, and to those of you who design transportation systems, is that most of the time people deal with extremely poor design rather successfully. And I think this is a very important observation. I expect that all of you today are, at the moment, dealing with rather poor seating. Some of you will manage better than others, but you're all dealing with it. You arrived here in less than adequate automobiles, via less than adequate transportation systems. You arrived here on planes that had less than adequate air traffic control. But more or less, most of the time, people do perform. That is what makes the understanding of human factors quite difficult.

Because we as humans are so resilient, often it's only when a failure of a mechanical system and a failure in a human system come together that we have disastrous consequences such as a DC-10 aircraft or a train crash. Only then, we begin to understand the significance of human factors. It's not a noble discipline however. It is a pedestrian day-to-day activity, that has a valid role inside the engineering and design process.

Within that context, I want to examine People Movers. This is a topic which appears to be a seemingly mundane issue in transportation. They're not exotic. They're not exciting. My argument however is that if we can find a role for the human in this system, and understand the role of human factors, then it is arguable that we will have a further understanding of the human as part of more sophisticated systems.

First of all, what is a People Mover? It's an automatic or remotely controlled system for the transportation of people. These systems generally move people within a building or between buildings. To some degree, it takes the person out of the *loop*. The result is that the person is not in control, rather the person's along for the ride.

Although it's a very limited system three points become apparent. First, it's still complex. A People Mover requires a complex physical interaction. A complex interaction of user population

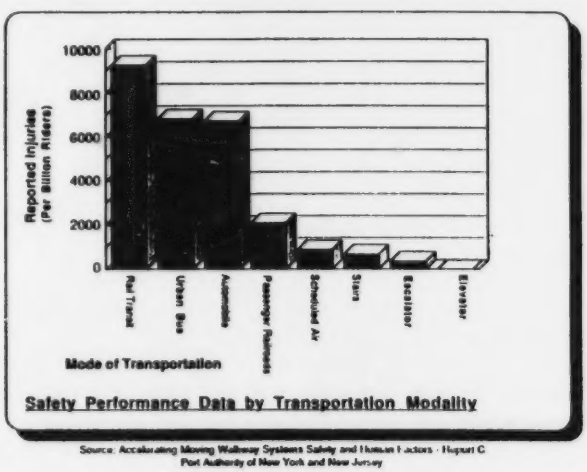
pools with a given design. A complex mechanical interaction for the user, trying to decide how to best use a given People Mover. And finally, a complex emotional interaction; I'm giving over myself to some device that can move me four to five times my normal walking speed.

Examination of People Movers also serves to reinforce the role of human factors in the context of systems design, task issues, hardware, environmental factors, and full life cycle design, a topic which has also been touched on this morning. Somebody has to design the system, somebody has to build it, and somebody will use it. It is also very important, in the context of People Movers, to remember that somebody has to dismantle it.

Let's start with some major issues and find out why we want People Movers to begin with. We've defined what they are. We are all familiar with relatively a wide variety of People Movers. Take escalators for example, they're not new technology.

Why would you want to use a People Mover in the first place? It's to move people. We understand the raw logic of moving people vertically through space by mechanisms but why horizontally? Allow me to present a few statistics to help us understand this. A number of studies recently completed in airports show that people in airports and train stations don't want to travel more than 244 meters (800 feet) under their own power. If you apply mechanical and heartrate workload models you'll find that, for many people, carrying luggage beyond this distance is really quite arduous. Ultimately we want to move people over long distances while minimizing their resultant physical turmoil.

It is also important to recognize the economy of People Movers. You can't have little golf carts shuttling everyone around, but today in Atlanta where we were running a People Mover project, it's possible to move a thousand people a hundred meters on a People Mover for just sixteen cents of electricity. That's very good economy.

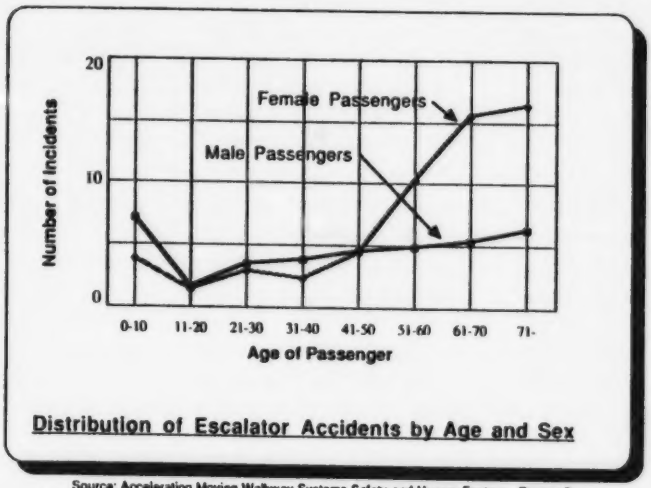


Source: Accelerating Moving Walkway Systems Safety and Human Factors - Report C
Port Authority of New York and New Jersey

Figure 1 Safety Performance by Transportation Modality

Once we've decided that we see a value in People Movers from an economy point of view, we have to take a look at them from a safety point of view. If we review the data, as illustrated in Figure 1, we see that elevators, escalators, and stairs have a certain accident rate per billion riders. The relative safety record of People Movers suggest that we would want to have people on escalators rather than stairs. This data reinforces our past operational experience. We now have people riding on escalators and we see that, per contact with escalator hour, there are

differentiating factors. For example, older women fall off escalators more than older men, and as a group they both fall off more than younger users (see Figure 2). These are all important human factors issues.



Source: Accelerating Moving Walkway Systems Safety and Human Factors - Report C
Port Authority of New York and New Jersey

Figure 2 Distribution of Escalator Accidents by Age and Sex

I think we've all accepted the role of human factors design in the "control/operator" *loop*, but how about the "just going along for the ride" *loop*. Where does the human fit in? Presumably we can take all of the complexities of ergonomics and say : design for what people are good at, design against what they are not good at.

If you rented a car, one particular model, and came here today, and you reached underneath your dash, you had a 50-50 chance of getting fresh air; or opening your hood. The same control might do either. From one point of view that was a success in modularity of design. It allowed the manufacturer to use one piece of tooling to accomplish multiple purposes. However, in another scenario where the hood does open up, the car may crash into another automobile killing twelve children. As interpreted by a lawyer, we are now looking at manslaughter, *with forethought*.

We can see that each of these examples lies on a continuum. The noble examples and the not so noble examples of human factors. What I wish to discuss is the creation of hassle-less environment. How do we make things easier to deal with? To reiterate some of Dr. Buck's comments, and to put them in context here, you can do a lot of reviews of the task that people are involved in. We took a lot of film of people trying to get on to and off from escalators and People Movers. Traditionally you look at the hardware, to some degree you look at the environment. One of the factors that is traditionally left out of the transportation *loop* is you can't deal with a lot of the management factors, you can't train people, and you can't deal with their expectations. Systems must be intuitive and quickly usable. Finally, you have to consider a wide variety of user populations : the young, the elderly, the handicapped, and even the blithering ergonomist who's getting off a plane flight. All must be considered in the range of human factors.

When a human factors person stands up in front of a congress such as this typically we point our finger at all sorts of problems. We can point our fingers at the problems with this system, we can ask questions about how is somebody supposed to slither across the ground and use

the emergency stop button that is three inches above the surface. We can point our fingers at this and say okay that seems to be an improvement but then we look at the caution sign that indicates "passengers only" and we raise the fundamental question of *who else* is going to get on a People Mover or escalator, other than a passenger. Is that not a distracting piece of information? So we typically become real pains in the neck by pointing out exceptions to the rule. We can go on a little bit further and point out that this is an unavoidable People Mover. If you decide not to use this device there's no alternative whatsoever. In this particular airport you have no choice except to crawl up across the superstructure.

All kinds of issues exist. One can do a sort of retrospective review of People Movers and go "Okay, I should differentiate where people get on and off, I should have different cues, perhaps have different textures, I should be considering pinch-points, I should be looking at user populations, I should be considering getting a variety of different vehicles on there, people that carry luggage, people in outdoor clothing, etc".

What I'd like to do is take this type of perspective approach and tell you about one design project for a People Mover. A People Mover similar to that illustrated, has been installed in Miami and Atlanta and other locations (Figure 3). You look at the whole system and it is evident that somebody has to operate the whole system. Thus there are traditional human factors considerations. A maintenance manual must be created. The equipment must be easily and safely serviced. And more importantly you have to figure out how people are supposed to fit inside of it as well as getting on and off.

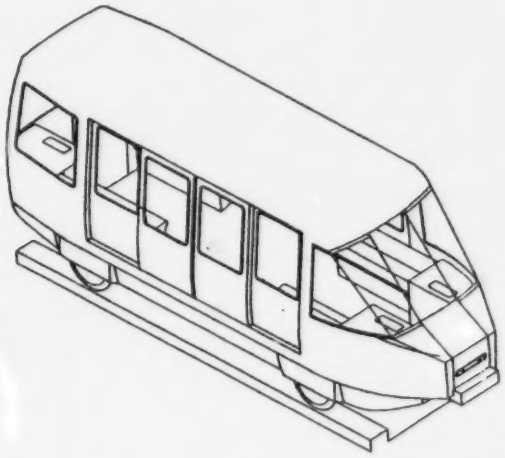


Figure 3 CAD Rendering of Typical People Mover

Traditionally the design process *loop* is that the industrial engineer, or the industrial designer, present you with a picture. "This is the People Mover; now would you please get people inside of this?" And of course one does that. You can always find different ways of fitting the person to the operation. The alternative is to take it from the inside and design out. Determine who's going to be there, with what amount of luggage, with what amount of ability, with what amount of desire to learn how to get on and off, with what amount of ability to resist G-forces during the acceleration, and with what amount of desire to sue if something goes wrong. You should attempt to determine all of these population factors.

It becomes apparent very quickly that the human factors engineer is not just dealing with systems failures such as a DC-10 crash. Rather, the work performed by the Human Factors per-

sonnel sounds very much like that of a marketing person. They're telling you how to make a system more palatable, how to get more user acceptance, whether or not you're in government or whether or not you're in Ford, how to position your products for more palatability is what it's all about — *getting acceptance*. How do we start this process. We can build mock-ups, we can suggest things.

One of the problems with the interface between the human factors person and the engineer, is the following statement: "It depends". Engineers like to believe that engineering is absolute and that standard deviation bars do not exist around any construct in engineering. Once, however, you introduce a human into the system we also get uncertainty. What was once a "If this — then that" logic, becomes a very conditional "it depends".

The human always introduces a wide range of variability. Nevertheless, one has to develop hard numbers for people that demand hard solutions. Consequently you can go through the whole range of designs and you start introducing computer tools such as SAMMIE (see Figure 4). This is just one solution. There are about fifty different man-model systems in the marketplace. This guy's name is SAMMIE

SAMMIE is articulated like a human. He moves like you do, he has the same number of joints, and we can give him the physical characteristics of a wide variety of populations.

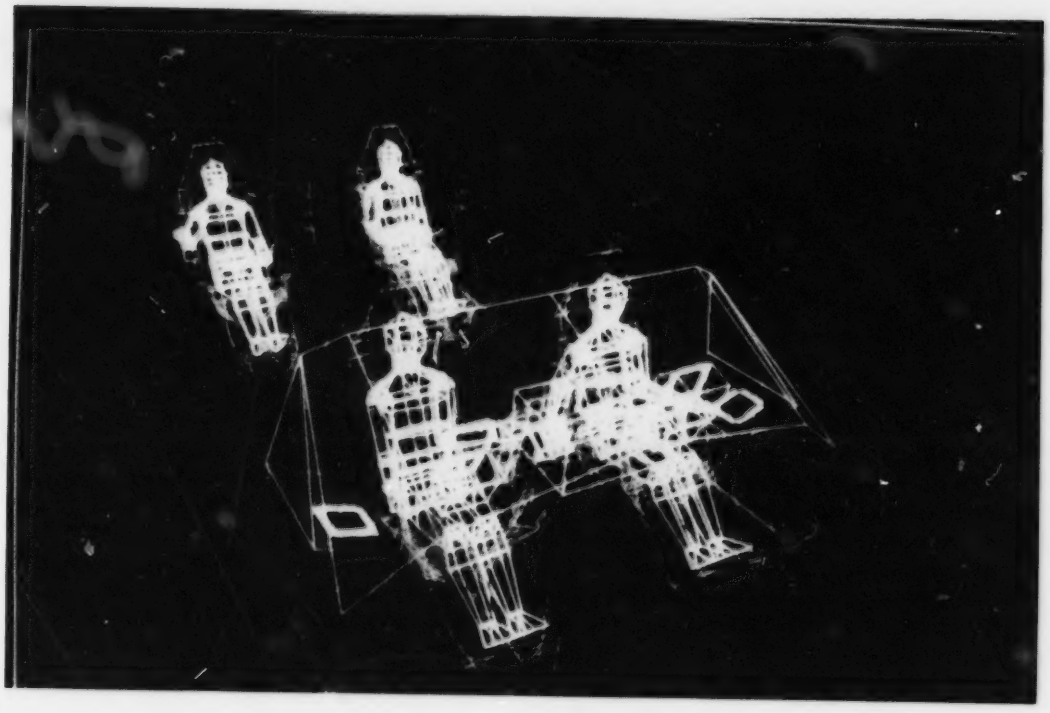


Figure 4 Graphic Output of SAMMIE Computer Model

We just finished a project for the Royal Saudi Airforce where we used *El Samid*. *El Samid* is the Arab version of SAMMIE. SAMMIE can be old or he can be young, we can give him the visual capability of a variety of populations, we can give him the motor response time of a variety of populations. We can, with sadness, make SAMMIE blind, and unable to walk.

If you're interested, you can see what SAMMIE sees in these traditional cockpit analyses. Any part of the system can be turned into a mirror to check for reflectances or to optimally locate mirrors in the design process. What's important here is that rather than somebody giving you the People Mover and saying fit the person into it, the human factors person, by using CAD has been able to actively participate in the design stream, and in that process, has not taken any extra time, in fact in many cases he or she has actually speeded up the process. Finally we can add surfaces and colours if you wish to visualize the product. This information can then directly input into a CAD system to produce engineering drawings. The system works in 3-D; make a change in one view and you've made a change in them all.

What's important in the People Mover scenario was that getting in early, we could say these are the expected user populations. We can define their mobility and their capability. Building a wire frame model, SAMMIE worked with the system and essentially changed the design. The net result was that the People Mover looked and performed differently. We were able to evaluate the entire concept of how people interact with the system and each other. How does the passenger get into the People Mover, buy their ticket? Early on in the design process you had a person working with system; a generic human being with human capability and human liability.

What are the benefits? We found three benefits as human factors engineers. First, it allowed us to communicate to the engineering community. Second, it enabled us to create better designs. And finally, it reduced design and development costs because we didn't have to go through a lot of early mock-ups. We were able to delay going to full model mock-ups until after the third generation design iteration rather than after the first.

People in transportation have the ability to learn from other people's experience. Fortunately you were not in the Hinton train crash. You were not in the DC-10 crash. And today you did not have a problem getting on and off the escalator. It's a shame that we experiment with the experience of others. This system allows us to push the learning curve a little bit and allows us to get in early in the design process. The potential benefits may be felt in all kinds of applications with different populations.

So we see a wide range in factors. A moving sidewalk is relatively simple. It's not exciting, and it doesn't have a lot of gloss, but it does demonstrate the role of the human in the design concept stage, the building stage, and in the maintenance process. What we see are tools to communicate with you, the transportation professionals, early on in the design process and allow many, many what-if scenarios. I think that makes the role of Human Factors more valid and fruitful for you and also makes your final products better fulfill their ultimate intended goals for people using them.

WORKSHOP 2
ERGONOMICS AND SAFETY

Preventing Human Error and Accident

Chairperson — P. Hallett,
Transport Canada

Pat Hallett, who is currently Chief of R&D Program Management with the Research and Development Directorate of Transport Canada, has held a number of positions locally, nationally, and internationally dealing with transportation safety. Following graduation in Civil Engineering from Carleton University in 1971, Pat joined the Regional Municipality of Ottawa-Carleton as a traffic studies and accident investigation engineer. From there, Pat joined the Road Safety Directorate of Transport Canada and held positions as road research and safety programs engineer. Under a leave of absence from Transport Canada Pat was offered an opportunity to work for two years with the Science, Technology and Industry Directorate of OECD in Paris, France. With OECD he was responsible for managing the sub-programs on urban public transport and traffic safety.

Before rejoining the world of research and development, Pat held policy positions with the former Ministry of State for Urban Affairs and later the Strategic Planning component of Transport Canada.

Research work that Pat has been involved in includes the assessment of road safety at night, safety of the use and handling of alternative fuels such as natural gas and methanol, and the assessment of performance indicators to measure/monitor freight and passenger transportation performance.

Pat currently manages special programs on Energy R&D and Transportation for Disabled Persons.

ATELIER 2
ERGONOMIE ET SÉCURITÉ

Comment prévenir les erreurs humaines à l'origine des accidents

Président — P. Hallett,
Transports Canada

Pat Hallett, actuellement chef de la Division gestion du programme R&D de la Direction générale, Recherche et développement, Transports Canada, a occupé divers postes aux niveaux local, national et international, dans le domaine de la sécurité des transports. Diplômé en génie civil de l'Université Carleton en 1971, il a amorcé sa carrière à la Municipalité régionale d'Ottawa-Carleton à titre d'ingénieur en circulation routière et enquêtes sur les accidents. Par la suite, il est passé à la Direction générale de la sécurité routière et de la réglementation automobile, Transports Canada, où il a occupé des postes d'ingénieur spécialisé en recherche routière et programmes de sécurité. Bénéficiant d'un congé de Transports Canada, il a eu l'occasion de travailler deux ans à la Direction générale de la Science, de la Technologie et de l'Industrie de l'OCDE à Paris en France. À cet endroit, il était en charge de programmes subsidiaires sur les transports collectifs et la sécurité de la circulation urbaine.

Avant d'entrer dans le monde de la recherche et du développement, Pat Hallett a travaillé à l'élaboration de politiques au sein de l'ancien ministère d'État aux Affaires publiques et, plus tard, à la Direction de la planification stratégique, Transports Canada.

Les travaux de recherche auxquels Pat Hallett a participé comprennent une évaluation de la sécurité routière la nuit, la sécurité dans l'utilisation et la manutention des carburants de remplacement comme le gaz naturel et le méthanol, l'évaluation des indicateurs de performance servant à mesurer ou contrôler l'efficacité des transports de marchandises et de passagers.

À l'heure actuelle, Pat Hallett dirige les programmes spéciaux R & D énergétiques et transport des handicapés.

Hinton Train Disaster

A. Smiley, Human Factors North, Inc.

Dr. Alison Smiley is president of Human Factors North, Inc., a Toronto-based consulting firm with five partners. Her research has primarily been in the assessment of vehicle operator behaviour as affected by experience, learning, fatigue, circadian rhythm, headlighting, and drugs. She has carried out these studies using instrumented cars, driving simulators, and laboratory tests. She has managed several extensive field experiments and is familiar with problems of collecting data from vehicles in field settings for the evaluation of human performance. She has also been involved in the specification of tasks, performance measures, and data logging characteristics for two driving simulators. She has been involved in accident investigation of train, tractor-trailer, and car accidents. She has also worked on human factors in nuclear power plants and is familiar with problems involving operator monitoring of complex automatic and semi-automatic systems. For the past five years she has been a member of the U.S. National Research Council Committee on the Simulator and Measurement of Driver Performance, and is currently also a member of the NRC Study Committee on BAC Standards for Commercial Drivers. She is president-elect of the Human Factors Association of Canada. Dr. Smiley teaches human factors part time at the University of Toronto. Her background includes masters and Ph.D. in systems design engineering, (University of Waterloo, 1971, 1978) and a bachelor's degree in mathematics (University of Western Ontario, 1970).

Introduction

On February 8th of 1986, at 8:41 in the morning on a clear day, a freight train that was 6000 feet long went past an approach signal (telling it to slow down) and then a red signal (telling it to stop) without slowing down. The freight train entered a piece of single track at 59 miles per hour where it collided with an oncoming passenger train going 49 miles per hour. The result of the collision was that 23 people were killed and over 30 million dollars worth of damage was done, not including any costs that may arise from law suits. The freight train's front end crew consisted of an engineer and a brakeman, both of whom were experienced and very familiar with the track that they were on. The same was true of the passenger train front end crew. The two trains were visible, each to the other, for a period of about twenty seconds. And yet during that time there was no brake application whatsoever.

What happened? The initial investigation looked at the possibilities of hardware failure by examining the brakes and the signals. Both of these were found to be in good working order, so the conclusion was "human error". When this conclusion was published in the newspapers I wrote to Foisy Commission of Inquiry into the Hinton Train Collision. I suggested that since human error was thought to be the cause of the accident, an ergonomist should be hired to look into why the human error occurred and what might be done to prevent similar errors in the future. I discovered later that a number of other ergonomists had written similar letters, and I was very fortunate to be chosen to carry out an ergonomic investigation. My investigation involved first, reading statements from the various crew members who had been on the track at the time of the accident as well as hundreds of pages of testimony from the Inquiry and second, riding on the train near the area where the accident occurred. During this train ride, I spent about eight hours talking to the crew members and observing the kind of work they were doing. As a result of this initial work, I decided that there were a number of factors which may have contributed to human error. I'm only going to discuss the major ones here.

Over and over again, I noticed in the statements of the crew members who had been on the track just prior to the accident, that people often had had only three or four hours sleep prior to going on shift. This led me to start investigating the work/rest schedules. In particular, the freight engineer himself had had, at the very most, three and a half hours sleep before he started out at 6:40 in the morning to return to his home base.

The second factor I thought might have contributed to the accident was the monotony of the job. I noticed this both as I was riding the train as well as in reading about the train driving task. Though considerable skill is required for driving trains, (for example, trying to put a train that is 6000 feet long into a siding that is 6500 feet long), a great deal of the time the engineer does not have very much to do and the job is quite monotonous, particularly in underpopulated areas. As it is very difficult for human operators to remain alert under such circumstances, I thought job monotony a second contributing factor. Thirdly, there was no back up in case of human failure. If somebody went through a red signal without stopping there was no automatic brake application. I will now discuss all of these issues in some detail.

Work/Rest Schedules

In looking at the work/rest schedules, there are a number of interesting factors. First, at the time of the accident, rest was optional and not mandatory. A crew member was able to book rest after being on shift for ten or eleven hours, but was not required to do so. As of March 1987, mandatory rest after shifts which have exceeded 8 hours is required. Second, the crew are on call 24 hours a day unless they book rest, or they have exceeded 4000 miles in one month. It is quite possible not to exceed 4000 miles in a month if the primary task is driving a lot of slow freight trains. There are no scheduled days off. There is no maximum shift length. When I looked at records for about 75 crew members, over the month of January 1986, I found among the 21 engineers, three had been on shifts that exceeded eighteen hours. Finally, the crew are judge of their own condition. It is up to the crew to decide at what point they are too tired to continue. Ergonomists are well aware that the more tired people are, the more incapable they are of accurately assessing their own condition. Overriding all this is the lack of scheduling of the freight trains, which meant that the hours of work were extremely erratic.

In order to understand the impact of this kind of schedule on performance I need to briefly describe something known as the circadian rhythm. The circadian rhythm is the term for the 24 hour physiological cycle of the body, by which various body functions such as temperature, heart rate, blood pressure, and adrenalin production rise during the day and fall at night. We sleep during the falling phase of the circadian rhythm, which is generally at night (unless one works extended night shifts). Mental alertness also follows this pattern, along with all these physiological changes. We are most alert during the day except for a brief period after lunch when alertness falls. The worst performance occurs about 3:00 a.m. Numerous studies have shown that performance at all kinds of jobs, train driving, truck driving, switchboard response, gas meter reading, etc., follows this rhythm, particularly being very poor in the early hours of the morning.

Our circadian rhythm is not actually a 24-hour cycle. If people are isolated, they tend to have circadian rhythms of 22–25 hours. We're kept to a 24-hour cycle by time keepers such as the changes in daylight and darkness, clock time, work schedules and so on. What happens if we work at night and sleep during the day? If we keep up night work on a regular basis for about 10 days, the circadian rhythm can eventually be altered. Plots of temperature over time will show that for workers on night shifts, after about 10 days the circadian rhythm adjusts so that temperature is high during the night. Along with this change in the peak temperature, go changes in mental alertness so that alertness is also now higher during the night than it would normally be. Although this adaptation takes place, it is never complete because of the conflict with the time keepers. It is difficult to sleep when the sun is up. Thus there is never a complete adjustment of the circadian rhythm. Another problem that occurs in adapting to night work, is that sleep during the day is less adequate than sleep at night. When sleep depth is measured with an electrocardiogram it is found to be much shorter and of much poorer quality. As a result, people tend to build up what is called a sleep debt. Every night that they work on night shift, they lose about an hour and a half of sleep. At the end of five days of working

nights, they have two days off. To pay off the sleep debt they will sleep up to twelve hours on those nights off.

Given all those facts, let's look at what the schedule was for the engineer who was driving the freight train in the month prior to the accident (see Figure 1 on following page). Each bar represents the length of the day's shift; the heavy lines indicate the start of the shift.

As can be seen, the starting times are totally erratic, so there is no chance for this person to settle into a circadian rhythm whereby performance is at an optimum. The second thing to notice is that there are very few days off. Hudson (the freight engineer) had a total of three separate days off during the month. These were not actually days off in the sense that he knew he was going to have them. He was available for duty but he wasn't called. So in those three separate days there was not enough time to pay off the kind of sleep debt that accumulates from this totally erratic schedule. A third feature is that the hours are quite long; he had worked 194 hours in the month prior to the accident. We know that for eight hour shifts, once total monthly hours exceed 170, absenteeism starts going up and productivity falls. This is even more true with a schedule like that of engineer Hudson. The schedule was bad enough, but considering Hudson's physical condition it was even worse. He was 49, had diabetes and high blood pressure, was a recovering alcoholic, and he had had a colostomy in the previous few months. So the combination of this schedule (which would induce chronic fatigue) and his physical condition, would lead one to expect that he would not be in an optimum condition for work and would find it difficult to maintain alert performance.

In other areas of transportation, fatigue has certainly been shown to be a factor in accidents. A recent study of serious truck accidents, showed that in 60 percent of cases, a fatigued driver was involved and in 40 percent of cases the fatigued driver was thought to be the primary cause of the accident. Their definition of fatigue was very conservative: the driver had to have been on duty more than 16 hours or had fallen asleep at the wheel. I feel it is a safe assumption that most people feel fatigue before they have been working for 16 hours.

Job Monotony

The problem for the crew of maintaining alertness when they were in a fatigued condition, was exacerbated by the fact that they were performing rather monotonous jobs much of the time. Just prior to the accident they had spent forty minutes going up a summit during which there was almost nothing to do. One of the clear findings from many studies of human behaviour is that people do not perform very well when they are faced with this kind of task. Even highly motivated subjects who are well rested and have a signal that is very clear, and in front of them for a long period of time, will still miss signals.

If this kind of vigilance task is carried out after reduced amount of sleep (Hudson had, at most, three and a half hours), and in work conditions where there is a lot of noise, heat, and so on, then vigilance performance is even worse. And all these factors were present in the accident situation.

A study in Germany looked at vigilance by recording responses to a reset alerting device. This is a device where the engineer has to hit a button every thirty seconds or so. If he doesn't hit the button, a warning light comes on after 25 seconds, another two and a half seconds later there is a loud buzzer. After a further two and a half seconds, the brakes are applied automatically. In a one month period, among 15,000 engineers there were 2,000 incidents in which the automatic brakes were applied. There were 20,000 incidents in 10 locomotives in which the acoustic signal came on. This suggests that vigilance is a very serious problem for train crews. On top of this there was a very clear circadian influence on the hourly pattern of responses.

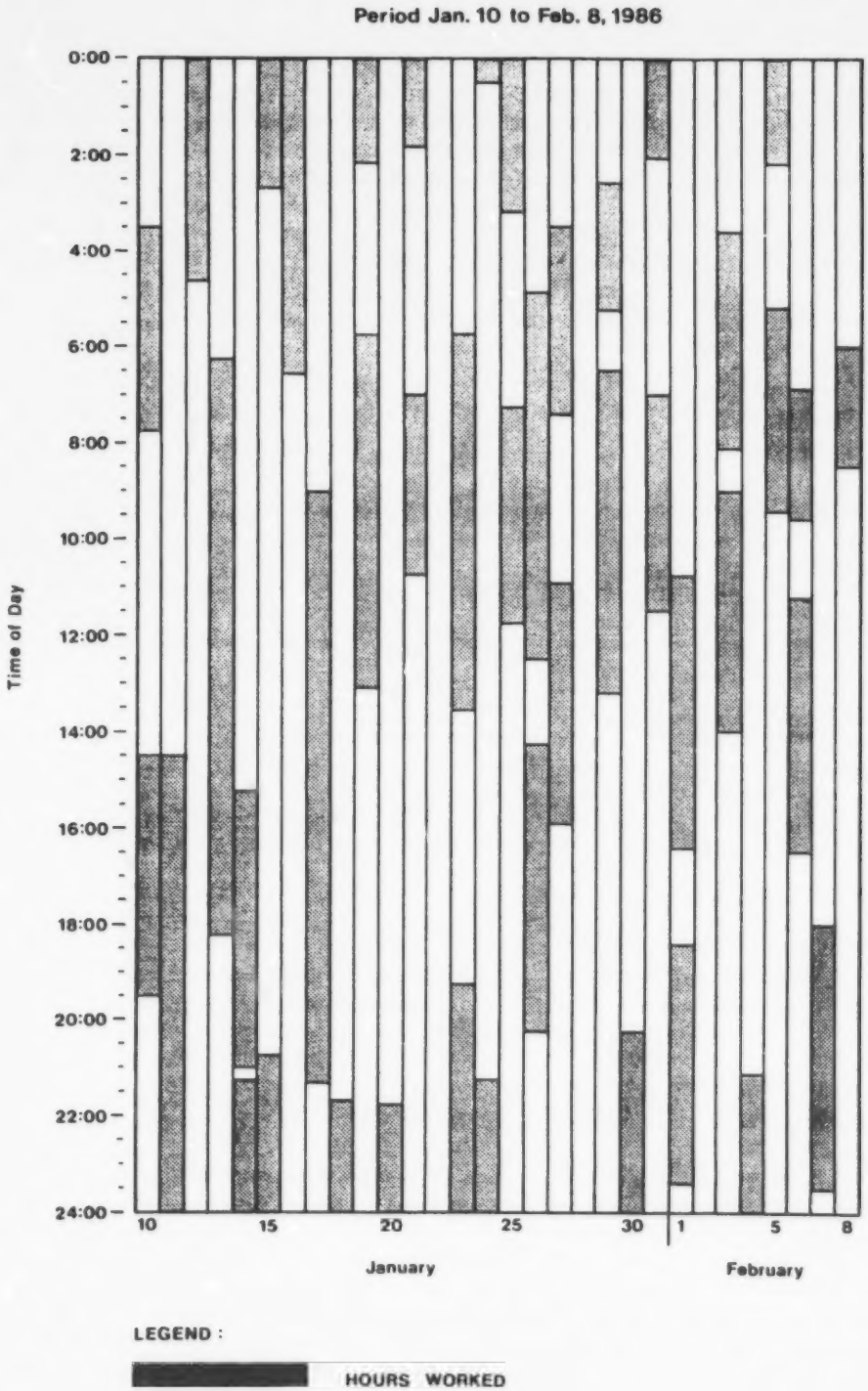


Figure 1

Shifts worked by engineer prior to Hinton disaster
(Reprinted by permission of Transport Canada)

The worst performance was at 3:00 a.m. and the longer the engineers had been on that job at that time of the morning, the worse their performance was. That is, an engineer who had been on the job for ten hours at 3:00 a.m. was more apt to miss a signal than someone who had been on the job for one or two hours.

Inadequate Planning for Human Error

The final major contributing factor to the train accident was inadequate planning for human error. Engineer Hudson had only one source of information telling him that he was going to meet another train. That was the signal. The dispatcher had warned him, in fact, about meeting two trains which he met about 20 minutes earlier, but the dispatcher had not warned him about the train that he in fact collided with. The decision of whether to inform engineers that they are going to meet trains is up to the discretion of the dispatcher.

One thing that is very clear from studies of information processing is that redundancy of information reduces error. It seems that if people are given more information about something, like meeting another train, the number of errors that are made in the task will very likely be reduced. Another related problem at Hinton was that the conductor is relied upon for pulling the emergency brake if the engineer goes through a red signal. Unfortunately the conductor is sitting a considerable way behind the engineer and can not see the signal at the same time as the engineer. He is supposed to look out into the woods and from a marker that he chooses, guess at what point the engineer sees the signal. He then is supposed to call ahead to the engineer, to confirm the colour of the signal. If the engineer doesn't respond, the conductor is supposed to pull the emergency brake. Unfortunately, it doesn't matter what the engineer responds because every signal light goes red as soon as the front end of the train passes it, so the conductor has no feedback. Also, there are numerous other reasons why the radio connection between the conductor and the engineer can be broken. Naturally, conductors are somewhat reluctant to pull the emergency brake, and in this case, possibly derail a very long, heavy train if it's merely because the engineer has got his radio set in a position where he can't hear the conductor or because of some problem with the landscape interfering with the communication.

Recommendations to the Commission of Inquiry

In conclusion, I made a number of recommendations as a result of my investigation. The first recommendation was that there should be mandatory rest both at the away-from-home terminal and at the home terminal. This I'm very happy to say is now being implemented.

The second recommendation was that there should be regular rest days in order to pay off the sleep debt that accumulates with working these very erratic hours.

The third recommendation was that there should be a maximum workload of 170 hours a month. We already know that this is the point at which productivity is reduced and absenteeism is increased in regularly scheduled work, let alone this kind of erratic schedule.

The fourth recommendation was, that the reset alerting devices that are now being put in all trains, (one hadn't been installed in the train involved in the collision) be properly maintained and properly installed. The fifth recommendation was that there should be an automatic braking system implemented such as has been in place in Europe for the past 35 years. With this system, if a train goes through a red signal the brakes are automatically applied. And finally, I recommended that the cabs should be ergonomically designed.

As I noted above, hours of work and rest are now beginning to be regulated. I look forward to further progress in this area as well as on the other recommendations.

Road Safety

R. Dewar, University of Calgary

Robert Dewar received his B.A. degree in Psychology from Mount Allison University in 1957, his M.A. from the University of Toronto in 1959, and his Ph.D. from McMaster University in 1965. From 1959 to 1962 he worked as a Clinical Psychologist in Saskatchewan. He is presently professor of Psychology at the University of Calgary, where he has been teaching since 1965. He teaches courses in ergonomics, perception, and environmental psychology. He has presented workshops on "Human Factors in Traffic Safety". He spent one year as visiting scientist at the Highway Safety Research Institute, University of Michigan, and five months as visiting scientist at the Australian Road Research Board, in Melbourne, Australia. He has conducted research on human factors in traffic safety (particularly driver information processing and perception of traffic signs) over the past 15 years. He is a member of the three Transportation Research Board committees (traffic control devices, user information needs and vehicle user characteristics), of the Council on Uniform Traffic Control Devices for Canada, and was for three years the Human Factors Society representative on the US National Committee on Uniform Traffic Control Devices, including two years on the executive committee. At the present time he is editing a book for the Institute of Transportation Engineers on "Human Factors in Highway Transportation".

Introduction

This paper is intended to give you a very brief introduction to the application of ergonomics to traffic safety. In applying ergonomics to road safety, a great many factors come into account. First of all I think there is probably no need to inform a group like this of the magnitude of the problem. Something in excess of 4000 traffic fatalities occurred on the highways in Canada last year, over 500 of them pedestrians; about 360 motorcyclists. This has changed relatively little since 1982. The causes for accidents are varied. Just as an example, in Saskatchewan in 1986 about 49 percent of fatal accidents were due to some human condition, and about 30 percent to human action. The most important single factor was driver inattention.

The Driving Task

Although I'm sure we all drive and we tend to think of it as fairly automatic behaviour, it's really very complicated, involving the roadway environment, the driver, the vehicle and interactions among these. Most models of driving include information intake, modulating factors such as age, maturation, psychological state, driving experience, etc., and response output. A good deal of work has shown the importance of driver attention relating to performance and traffic accidents.

The human in the system can be either the driver, which seems to get most of the attention, or the pedestrian or cyclist. Ergonomics comes into it in terms of looking at driver ability and limitations, particularly the driver-vehicle and driver roadway interaction. Among the important features here are the actual design of the roadway and the vehicle.

Information Processing

Leslie Buck, in his talk, set out very nicely the importance of the human as an information processor in a variety of tasks and certainly in connection with driving. The task of operating a motor vehicle has become much more cognitive in the last two or three decades than it was earlier. Not nearly as much physical energy and stamina are required. And as we get more and more high technology applied in vehicles then it becomes even more of a monitoring/vigilance/cognitive task. A look at the requirements, particularly the visual requirements, for driving would seem to be fairly obvious. I'm sure you've all had a driver licensing test at some

point in the past, although some of the older members of the audience perhaps haven't. In taking such a test, what's involved are measures of colour vision, peripheral vision, depth, static acuity. But surprisingly, relatively few of these sensory abilities seem to have any relationship to accidents. In-depth studies of accidents done in the U.S. and England have shown that most of these have very poor correlations with accident rate. A couple of the ones that do seem to relate to accident causation involve central movement in depth, (the ability to perceive something changing in relative size as is the case when you approach another vehicle in a passing manoeuvre, for example) and relative angular movement (ability to perceive something accurately as it's moving relative to you). And of course this is exactly the situation in driving; it's a dynamic situation, not a static one. We test static acuity and this isn't really what's involved in the driving task. Even these particular abilities only related closely to accidents with older drivers, drivers over 55 years of age.

In view of the apparent lack of relationship between these various sensory abilities, which we test in driver licensing, and accidents, then what is it that we should be looking at? The important thing turns out to be whether the driver is looking in the right place at the right time, ie. if he or she is paying attention. In-depth studies of accidents, again based on work done in the U.S. and England, showed that over 40 percent of accidents involve human error that is specifically related to information processing and perception — anything from internal distraction and pre-occupation, to failure to be attending to what's happening on the road. These factors are really difficult to get at, partly because it's hard to know what's going on inside the driver's head at the time immediately prior to an accident.

Roadway and Vehicle Design

Among the important ergonomics considerations here are both design of vehicles and design of roadways. In terms of vehicle design, these include basic anthropometry (the size of the driver), ability to reach controls, ability to see displays, and driver eye height. The standard for the design of roadways, until about twenty years ago, in North America was in about 4 feet, assuming the driver's eye height was that far above the roadway. If you go back far enough it was 4 1/2 feet. Now with smaller vehicles these standards have been dropped to about 3 1/2 feet, at least in the U.S. If you assume that the driver's eye is a foot lower, you've got to design your roadway and your safe stopping sight distance quite differently. Roadways are often designed in ways that violate driver expectancy and lead to accidents.

Another factor in connection with vehicle design is the driver's ability to find and correctly operate various controls. A study was done which showed that drivers have considerable difficulty locating fairly simple controls such as air conditioning and a more basic one, the starter. In one study, drivers took an average of about 19 seconds to locate and operate certain control devices of one model. In another model from the same manufacturer it took about three seconds. Huge variations exist in layout and design of controls and displays, which very often violate drivers' expectancy and make life difficult, especially in an emergency situation. Other things relating to vehicle design involve operator overload. A study just conducted by one of my graduate students looked at the ability of bus drivers to divide attention in a complex information processing task. We found that bus drivers who had accidents had much more difficulty at switching attention and doing more than one thing at a time. Ergonomics has also done a lot to develop safety features with regard to vehicle design, with such apparently simple things as day time running lights. Dennis Attwood, formerly with Transport Canada, did a lot of this work. High-mounted brake lights, which are now standard on new automobiles in North America, have been very effective. The early statistics on that suggest that rear end collisions are probably reduced 30 to 50 percent.

Traffic Control Devices

Something that I'm more familiar with are traffic control devices. This is part of the roadway environment. Very often they are poorly designed, poorly placed, poorly maintained and people often have difficulties (particularly with regard to symbols on traffic signs) because they can't be seen at an adequate distance or because they don't understand them. My own experience with regard to the development of these relates primarily to traffic control device committees such as the Canadian and the U.S. ones. The techniques for developing traffic sign symbols are really rather frightening in terms of their inadequacy. The way they've gone about it traditionally, although this is changing a bit now, is as follows. First of all a need is determined for a traffic sign symbol to convey a message to drivers. A committee is formed of about a dozen people and then they send out a brief questionnaire to committee members asking them what they think, and to draft up some potential designs, and then they vote on these and the next thing you know a new symbol is in the traffic sign manual, without any formal measures of whether drivers understand them; engineers do, but do the drivers? How legible are they? Can they be seen at night? Are they easily confused with other symbols in the system? These things are basic ergonomics questions which very frequently are not answered.

Individual Differences

With regard to individual differences, as we've already seen, we have a great variety of users. Drivers come in all shapes, sizes and ages, considering that you can start driving a vehicle at the age of 14, at least in Alberta with a beginners licence. There are a significant number of drivers over 80 years old. As we get more and more older drivers on the road, we're going to come up with problems for obvious reasons. Their reaction times are slower, they have difficulty in dividing attention, are more easily confused from information overload and driving in strange environments, etc. Another factor is personality. I think it was a Canadian psychiatrist that once said "We drive as we live".

That sounds a bit corny but the evidence suggests that's probably the case. Although work on personality doesn't suggest any specific characteristics that relate to high accident rate, accidents do seem to be related to impulsivity, immaturity, hostility, and factors like that. These tie in with motivational factors.

Risk taking is a very important element in traffic safety. It relates directly to motivation but it's quite difficult to get at. Often people misperceive risks simply because of inexperience or inability to translate the information they see on the roadway into a perception of a hazard. We promote risk taking in automobile advertising when we are told "our vehicle creates excitement for you" and we see people driving over sand dunes and taking two meters of air as they go. Things like this really get young drivers excited about speed. Emotional factors are also important here, as they are in many other types of work, where people can be impaired emotionally through depression, frustration, and anxiety. Research shows higher accident rates among drivers who are depressed or emotionally upset.

Driver Education and Licensing

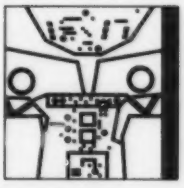
The areas where ergonomics really doesn't come in nearly as much as it should are driver licensing and driver education. Although some people in the audience might want to take exception, there doesn't seem to be a lot of good evidence that driver education makes much difference in terms of accident rate. This is partly because we're teaching people the mechanics of driving and not the information processing skills and attitudes which really seem to make a difference. Likewise with licensing; it is very easy to get a license in this country. This probably breeds a bit of disrespect. It's so easy to get a license that driving a vehicle must be seen by beginners as a relatively simple task.

Ergonomics Techniques

As an illustration of methodology we'll examine some of the techniques used in looking at traffic signs in our laboratory. Wheeling people in a wheelchair toward a sign to get at legibility distance was one of them which we validated with on the-road measures of signs. We looked at both lettering and numbering and concluded through some of our studies that the Canadian/U.S. system is best for lettering and the Dutch system best for numbering. But they weren't sufficiently different to bother making any major changes. The railway crossbuck sign was examined, including a yellow and black version and the red and white one which is now coming into use in Canada. At Toronto Airport we looked at existing road signs and did a simulation in which we used something very simple, just drawings of a situation, tested these and came up with recommendations for changes. Changes were made in several locations at the airport and traffic then moved somewhat more smoothly.

A lot of our work was laboratory work but we did one field study in which we looked at hazardous cargo signs. Big differences in the legibility distances of these signs were found, and many designs had ergonomics problems. One of my students did a study in which we put transverse striping on the roadway on an off ramp from a freeway. Although we slowed drivers down a little bit, about 2 or 3 kilometres an hour, the number of high speeding drivers dropped by 40 percent. Likewise, we got similar results with a sign which gave feedback about how many people were speeding. Just telling drivers how many people were speeding reduced the number of excess speeders (who were going more than 40 kilometres an hour over the limit) by 40 percent. That just gives you a few examples of some of the applications of ergonomics to traffic safety.

WORKSHOP 3
DISPLAY SYSTEMS



Letting the Operator Know What is Going On

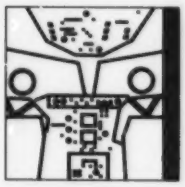
Chairperson — F. Legault,
Transport Canada

1981 Bachelor of Applied Sciences — Mechanical Engineering from the University of Carleton.

1981 to 1982 Test Engineer with TES Limited conducting vehicle safety and research testing, including occupant/vehicle interface and transportation of the disabled.

1982 to Present Regulations engineer with the Road Safety and Motor Vehicle Regulations Directorate of Transport Canada on crash protection of vehicle occupants, specializing in seat belts, child restraint systems and restraints and vehicles for the disabled. Author of papers on testing of restraint systems for disabled child and vehicles for disabled drivers. Involved in various committees related to occupant protection.

ATELIER 3
SYSTÈMES DE VISUALISATION



Bien informer l'opérateur : une nécessité impérieuse

Président — F. Legault,
Transports Canada

1981 Baccalauréat ès sciences appliquées (génie mécanique) de l'Université Carleton.

1981 à 1982 Ingénieure d'essais chez TES Limited, chargée d'essais et de recherche en sécurité des véhicules, y compris les interfaces occupants/véhicule et le transport des handicapés.

Depuis 1982 Ingénieure de sécurité à la Direction générale de la sécurité routière et de la réglementation automobile, chargée de la réglementation de la protection des passagers en cas de collision et, plus particulièrement, des ceintures de sécurité, systèmes de retenue dans les véhicules conçus pour les handicapés. France Legault a rédigé plusieurs articles sur l'essai des systèmes de retenue des enfants handicapés et sur les véhicules adaptés à la conduite par des handicapés. Elle participe également aux travaux de divers comités s'intéressant à la protection des passagers de véhicules automobiles.

Intelligent Systems

Y. Ian Noy, MASc., P.Eng.

Ian Noy is currently Chief of the Ergonomics Division of Transport Canada's Road Safety Branch. He received his MASc. degree in Industrial Engineering from the University of Toronto in 1973, specializing in human factors. Prior to his current appointment, he worked at the Defence and Civil Institute of Environmental Medicine (DCIEM) on a variety of man-machine systems.

At Transport Canada, he performs human performance research to support the development of vehicle safety standards and other accident countermeasures. Past research has dealt with the effects of drugs on driving and the development of an Intoxication Warning Device to deter drunk drivers. Currently, Ian is conducting research on ergonomics issues related to the use of intelligent displays in vehicles.

Ian is very active within the ergonomics profession. He is a past president of the Human Factors Association of Canada/Association canadienne d'ergonomie (HFAC/ACE) and is currently serving on the Executive of the International Ergonomics Association (IEA). He is also a member of the Human Factors Society (HFS) and Transportation Research Board (TRB) Committee on Simulation and the Measurement of Driving.

Introduction

I would like to extend my thanks to the organizing committee for inviting me to describe our work in the area of automotive displays. This workshop is entitled "Display Systems" and, interestingly, the subtitle reads "Letting The Operator Know What Is Going On". I am not sure whether or not this is intended to convey that it is necessarily desirable or beneficial to let the operator know what is going on. While I would agree with a call for more effective communication across the driver interface, this does not imply that the driver would benefit from knowing everthing that is going on. In fact, the work that I will be describing represents an attempt to examine to what extent drivers can utilize information presented to them on dash-mounted displays. Although our work is focused on the automobile, the ergonomics concerns and research approach that I will outline extend to other modes of transportation.

As France indicated, I am with the Ergonomics Division of Transport Canada's Road Safety Branch. The Branch has the responsibility for the research and development of accident countermeasures. For example, the Branch manages the Canadian Motor Vehicle Safety Standard which is a major road safety instrument. The Ergonomics Division supports the activities of the Branch by performing hands-on human factors research in a variety of man-machine problem areas. The ergonomics work that we are performing in the area of automotive displays may indicate a need to upgrade the Canadian Motor Vehicle Safety Standard.

What are Intelligent Displays?

The common use of the phrase "intelligent displays" refers to the computer-driven electronic displays which present processed information to the driver. This definition speaks to the technology underlying these systems. I think that it may be more instructive to redefine intelligence in terms reflecting the quality of information rather than its origin or medium of presentation. That is, as an ergonomist, I would prefer a definition that speaks to the implementation of new technology rather than the technology itself. Hence, I would prefer to define an intelligent display as an information system that "knows" what to communicate, when to communicate, and how to communicate. What, when and how are examples of the questions that must be addressed before we undertake to let the operator know what is going on. Some of you might say that the displays which can achieve this level of intelligence are really "expert" intelligent display systems. Definitions aside, it is important to recognize that the essence of this presen-

tation is "information management" in vehicles. The thrust behind our work is the recognition that proper information management must be based on an understanding of how humans perceive, process, and use information.

The Mobile Multi-Purpose Interface

We were shown this morning how rapid advances in micro processors, artificial intelligence, expert systems and other technologies such as display hardware have revolutionized the airplane cockpit. These technologies are also becoming prevalent on the dashboard of modern road vehicles. Pressure is being felt by automotive manufacturers to introduce this technology in order to increase their market share, to improve driver productivity (as evidenced by the introduction of the cellular telephone), and to enhance driver performance and safety. The interplay of technological innovation and the desire to implement new technology quickly is transforming the future automobile into what can be termed "the mobile multi-purpose interface".

The evolution of the mobile multi-purpose interface within an historical context begins with the old horse-and-buggy days, the driver relied on the horse to keep him out of trouble — he was aided by horse intelligence. More precisely, the driver assumed responsibility for supervisory control while the horse did most of the tracking (lane keeping). But with the advent of the automobile the horse was replaced by a non-intelligent engine and the automobile driver now had to assume responsibility for tracking as well as supervisory control. Technology continued to advance and soon provisions were being made to permit those that could afford specialized equipment to perform work enroute. The next step may well be to combine driving functions and non driving functions in one integrated interface, giving the driver maximum flexibility in configuring his/her mobile workstation.

To give you a good impression of the current state-of-the-art and what the future might hold, some of the technological highlights of the interface evolution are set out below:

1. Projected use of electronics (03) By the year 2000, GM expects that investment in electronics per vehicle will reach $2,000 compared with the current $500.
2. 1978 Cadillac Seville — first electronic digital display
3. 1984 Chev Corvette — first LCD cluster
4. 1984 Chev Corvette — closer look at the instrument panel
5. 1985 Toyota Soarer — first full colour CRT
6. 1986 Buick Riviera — first monochromatic CRT
7. 1986 Buick Riviera — closer look at the touch sensitive display
8. 1986 Lincoln Town Car — Vacuum fluorescent
9. 1986 Subura XT — 3D display format
10. 1986 Lancia Y-10 — electromech & LED displays
11. 1986 Opel Senator — transflective LCD
12. 1986 LeBaron — vacuum fluorescent displays
13. Heads-up display (HUD) concepts for future vehicles
14. HUD & Forward Looking Infra-Red (FLIR) concept
15. Etak Navigator moving map display

16. CRT-Office concept (the mobile multi-purpose interface?)
17. Chevrolet Express — having 6 CRT's
18. Olds Aerotech — seethrough LCD HUD
19. Buick Wildcat — the hub display concept
20. Pontiac Pursuit — polychromatic display
21. GM Blazer — an airplane cockpit concept?

The trend evidenced by these highlights implies a radical transformation of the driving task as we know it. As Bob Dewar indicated this morning, the traditional components of the driving task are lane tracking and obstacle avoidance. In addition, a third component can be projected — interacting with auxiliary displays. Drivers will have to monitor status displays, to search pictorial and text displays and perform various kinds of manipulations on displayed data.

Why Focus on Intelligent Displays?

There are two important reasons for focusing our efforts on in–vehicle displays at this time (as opposed to other automotive systems impacted by new technology). As I pointed out earlier, the Canadian Motor Vehicle Safety Standard ensures that all motor vehicles manufactured or imported to Canada meet minimum design and performance criteria. The Standard does not presently cover display systems. That is, there are no criteria dealing with display legibility, location, number, use, etc. This is largely because hitherto there was no need for regulation — displays play a minimal role in accident causation. Even today, automobile dashboards do not capture much of the driver's visual attention since virtually all driving-relevant information originates outside the vehicle. However, the forecast of more extensive and intensive use of in-vehicle displays is changing the picture and there is a need to consider the future role of government regulation in this area.

Another very important reason for focusing ergonomics efforts on in-vehicle information systems is that automotive engineers are less able to predict drivers' ability to integrate, interpret and use the information presented to them than they are able to predict drivers' responses to, say, new controls. Automotive engineers are well trained in control science, not so well trained in the cognitive sciences. Hence, the design of intelligent displays is an area in which ergonomists can make important contributions and complement the work of design engineers.

The Role of Ergonomics

If properly implemented, new technology offers significant benefits. There are definite opportunities to improve safety and performance and to reduce travel time and fuel. However, without ergonomics principles to aid in the development of new displays, there are serious risks as well. For example, traffic safety could be hampered by increased driver inattention, misinformation, information overload and negative transfer. Bob Dewar, in his earlier presentation, provided an excellent discussion of factors affecting driver attention and performance. I would like to stress that new technology does not alter these relationships or the factors affecting driving performance. New technology does, however, offer vastly increased scope for creating new interface designs. Hence, some problems will become much more salient as competition for the driver's visual attention and mental workload increase. There is considerable evidence from in-depth accident investigations that driver inattention, or improper lookout, is implicated in a large proportion of accidents. Evidently, drivers are already experiencing difficulties in allocating their attention appropriately among elements of the external environment. What will happen when in-vehicle displays enter the competition for the driver's visual attention?

Research Objectives

Figure 1 presents a simplified theoretical framework for our current studies. The diagram shows that the relationship between information displays and driving performance is mediated through attentional mechanisms. The driver will allocate his/her attention on the basis of internalized models of what is happening and prioritization of awaiting tasks.

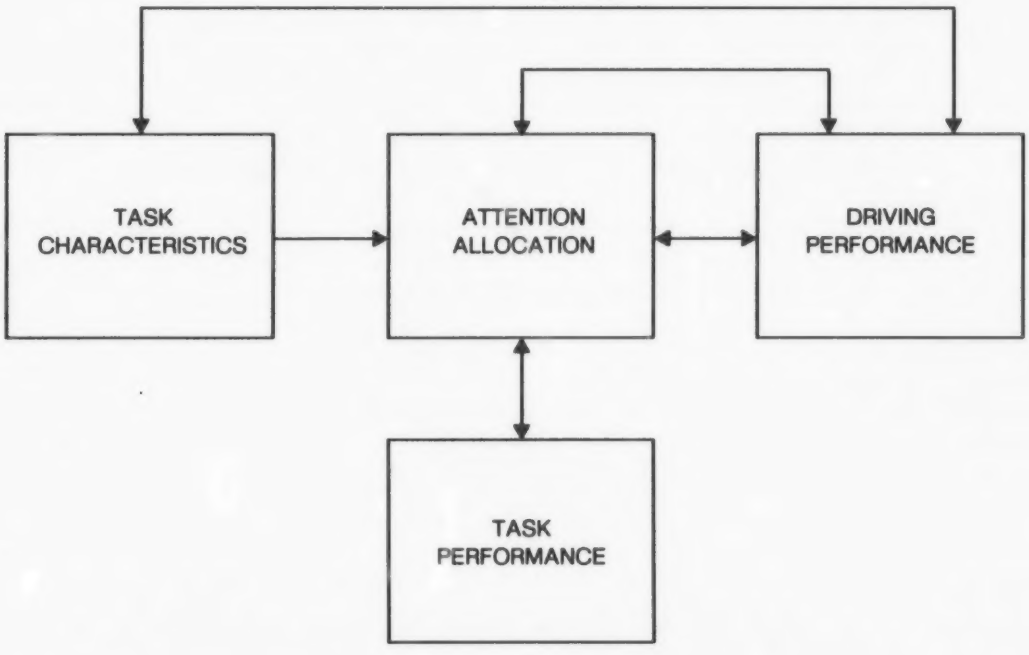


Figure 1 Theoretical Framework for Dual Task Driving Research

The objective of our current research is to examine the relationship between task characteristics, ie., the kinds of tasks that may be presented on intelligent displays and driving performance. Will displays affect the driver's ability to drive safely? We are interested in examining the relationship between attention allocation (looking patterns) and driving. The former relationship between task characterisitics and performance may lead to design guidelines, while the latter, ie., the relationship between attention and driving, may lead to performance guidelines. A simple example of the latter may be a time criteria for the acquisition of displayed information.

I want to close with a few words on the research methodology that we have adopted. As we are primarily interested in identifying the key factors affecting drivers' abilities to drive and perform concurrent auxiliary tasks, we have selected dual task techniques in which the primary task, driving, is time-shared with a computer-based secondary task presented on a dash-mounted CRT. We are employing factorial experimental designs to systematically study the factors we believe could play an important role in time-shared behaviour and performance. These are; task structure (spatial versus verbal), task difficulty, task utility and driving demand. These studies are being conducted using a six degrees of freedom motion base simulator featuring

full colour computer-generated imagery. We have selected simulation primarily for reasons of safety, ability to manipulate and randomize conditions and control extraneous variables. Other considerations include ease of re-engineering, logistics and availability of hardware for recording the 25 or so dependent measures of interest. We have developed a technique for monitoring subjects' visual attention and we will be able to compare data corresponding to periods of looking inside the vehicle with data corresponding to periods of looking at the road.

Ergonomics and Arctic Navigation

J. Ells, University of Calgary

Jerry Ells received his Ph.D. in cognitive psychology emphasizing human information processing and attention from the University of Oregon in 1970. His research efforts during the past several years have been divided between laboratory studies of human information processing and the application of information processing paradigms and theory to problems in ergonomics. The applied research has included an evaluation of a wide variety of informational and traffic signage systems and an examination of relationships between task performance and factors such as noise, vibration, stress, limited visibility, etc. Currently, his applied research is focused on an ergonomic evaluation of computerized navigational systems designed for shipboard use in Arctic waters. His present laboratory research project, funded by the Natural Sciences and Engineering Council of Canada, is designed to examine acquisition, control and attentional requirements of automated behaviours in complex tasks demanding rapid decisions and response precision.

Introduction

This presentation summarizes an ergonomic assessment of an integrated computer-based system designed by Intera Technologies to receive, store, and display airborne navigational radar data down-linked for shipboard use in Arctic waters. The initial phase of the research project focused on identifying ways in which the user interface and software system could be improved or refined for shipboard personnel. This involved a formal task analysis followed by structured interviews and testing sessions with navigators and ice specialists who had varying amounts of experience with SAR data. The subsequent phase of the project explored the accuracy with which experienced ice observers could assess and classify ice using digital radar imagery displayed at several different resolutions. The purpose of the study was to answer several questions concerning the optimum design of the screen layout, display resolution, and amount of information required for ice classification using the video display system as well as to test its suitability for use as a training simulator.

The User Interface

STAR-VUE is a real-time image reception and display workstation for SAR (Synthetic Aperture Radar) radar imagery. A radar image may be received in "real time" as the aircraft is actively imaging, or transmitted to or from another STAR-VUE workstation. The downlinked imagery can be examined as it is being received on a graphics display, or can be stored for later viewing. The screen displays a row of "soft" buttons, where a series of menus are shown for selection of options, positioned below an area for maps and imagery. The operator interacts with the display by means of both a rollerball, which enables movement of cursors around the screen, and a button to initiate selected operations. Different cursors perform different functions, ie. one selects menu options, another roams across the image to select an area of interest and a third draws lines on the image to plot a ship's course. For example, a selection from the main menu allows an operator to view a map which shows the positions of all flightlines available for viewing. With the cursor, the operator can select a flightline for display. Activation of another menu button displays the SAR imagery of that flightline on the left hand portion of the screen for global viewing and strategic planning. A cursor box can be moved to any location on the image to choose an area for higher resolution, to be displayed on the right-hand side of the screen. Another menu then enables a route to be drawn on that image. The user interface is designed to be easily operated by those who have had little or no previous interaction with computer systems. Prior to preparing a protocol to be used in the development of training and testing procedures for interaction with STAR-VUE, a task analysis was conducted. All functions involving the screen, rollerball and operating buttons were examined to explore the nature of the tasks necessary for interaction with the instrument.

The experimenter outlined the function, tasks involved in operating that function, and any obvious problems for each button for all menus. This served to familiarize the experimenter with the interface, to form the basis of a training procedure and to gain initial feedback from the experimenter, who was a naive user. Having become familiar with the system by means of the task analysis, the experimenter carried out four pilot interviews with Intera employees. On the basis of their comments and task analysis, the interview and training protocol were then developed. Testing sessions were conducted at Intera's laboratory, Calgary, and at Canarctic's Offices, Ottawa, using a free-standing STAR-VUE system operationally identical to that which was to be tested aboard the M.V. Arctic following the analysis of the data generated in the laboratory settings. Subjects were personnel with extensive Arctic experience from Canarctic, Coastguard, and Gulf including ships' captains and officers and research personnel highly familiar with SAR imagery and ice interpretation.

Subjects were seated beside the experimenter at the STAR-VUE workstation facing the screen. During the session, subjects were familiarized with the display and controls, interviewed prior to their participation in the training trials, tested on several tasks, and finally were reinterviewed at the end of the session. Each session was subdivided into four parts: the initial interview, training, testing, and the post-experimental evaluative interview.

The initial interview consisted of a discussion designed to establish the pre-test expectations and background of each subject and to discover the limitations of ice navigation equipment being presently used. Questions were asked regarding: (a) subject's background; (b) past use of equipment; (c) user requirements of STAR-VUE; and (d) attitudes to and experience with computers versus hardcopy. The experimenter then guided each subject through the operation of STAR-VUE according to a predetermined protocol. During this interaction, a series of questions were asked relating to ease of operations and STAR-VUE images. Finally, during the post-experimental interview, any remaining questions about operations and images and possible alternative design features of the system and any problems arising during interaction were discussed. In the case of the Canarctic and Coastguard groups, this was supplemented with a meeting at which all subjects and members of the research team were present. (For detailed results, please refer to T.D.C. report: TP 8221E.) The testing and interviewing of employees from Intera, Canarctic, Gulf and Coastguard resulted in a number of supportive statements praising STAR-VUE and also pointed out some problem areas with the system which required further research. Following discussions with the human factors research team, STAR-VUE designers implemented a number of software changes to alleviate the problems experienced with the work station prior to the field test on the M.V. Arctic.

SAR Imagery and Ice Classification

STAR-VUE is an instrument designed to present high resolution SAR imagery received in real-time from airborne radar systems. It will be used for ice interpretation by ship's navigators and offshore rig personnel. In order to optimize STAR-VUE's functions, alternative methods for presenting the imagery to its users are being investigated. Research designed to examine the efficiency of ice classification as a function of image resolution and/or ice type was conducted at the Intera laboratories.

Seven male subjects participated in the study, six of whom were highly experienced at ice interpretation from SAR images. One had some experience but was not considered to be at the expert level. Five, including the latter, were Intera employees, and two were invited from Gulf to take part. Subjects were tested individually and were not paid for their time.

The task involved responding to each of 125 synthetic aperture radar (SAR) images displayed by way of a DEC PDP 11/73 Processor on a 640 x 480 pixel (40 x 30 centimeters) display.

Each image portrayed a view of sea ice and covered most of the screen. On each trial, a question specifying an ice-type was presented on the screen, for example, "Is this old ice? Yes/No?" This was followed by an image and a yellow cursor box. The ice within the box was to be classified. Subjects were to respond by depressing one of two keys labelled "yes/no", and then to rate the confidence of their judgment. An average of five different images of each of five ice types appeared at five different resolutions, constituting 125 images in all. An employee of INTERA with extensive experience in SAR and ice imagery interpretation was responsible for choosing, classifying and displaying the 125 images for the experiment. The classification system he used was from the standard AES Manual of Sea-Ice Reporting (Atmospheric Environment Service, 1980). The manual's description for the "Rubbled/ridged" category was slightly adapted for the purposes of the experiment. A hardcopy textual description of the ice-type classes used was available alongside the apparatus. The ice types represented were: 1) Open water/new ice; (2) Young ice; (3) First-year ice; (4) Old ice; and (5) Rubbled/ridged ice. The ice types were presented at resolutions of 12, 24, 48, 96 and 192 meters per pixel. There were five blocks of trials, one for each resolution, presented in a different random order for each subject. In each block, there were 25 trials, an average of five images of each ice type. The ice types were mixed randomly within the blocks. Subjects sat approximately one meter from the screen and responded on a standard keyboard, using the 'f' key labelled 'Y' for a 'yes' response, the 'j' key labelled 'N' for a 'no' response, the 1,2 and 3 keys of the keyboard for confidence level responses and the space bar for moving from trial to trial. Within each block of trials, the subject was presented with five questions for each ice type. Four of the five questions matched the original classification of the image to follow, while the remaining question was a mismatch, requiring a 'no' resonse to be in agreement. Thus, 20% of the answers given in the feedback were 'no'. The data for response time, confidence level ratings and classification disagreements were subjected to statistical analysis. Comments made during and after the experiment were recorded and later served to aid interpretation of the results and to give some insight into the ice classification process. In general, the data indicated (1) that the observers required significantly more time to classify certain ice types (especially rubbled/ridged ice); (2) confidence of classification varied with both type of ice and image resolution; and (3) perhaps most importantly, the observers viewing the images disagreed substantially with respect to their classifications. These and related results have generated several questions concerning ice classification based on SAR imagery which are currently being investigated.

WORKSHOP 4
HUMAN/COMPUTER WORK STATIONS

Accommodating the VDT Operator

Chairperson — R. Nishizaki,
Transportation Development Centre

Mr. Nishizaki is a graduate in Mechanical Engineering from the University of British Columbia. He also holds a Postgraduate Diploma in Management from McGill University. His professional career has been in the field of research and development, both in the aerospace industry and with the Transportation Development Centre of Transport Canada.

He started with Bristol Aircraft Ltd. in Bristol, England in 1956 working on helicopter design and development prior to joining Canadair Ltd. in Montreal in 1959. At Canadair, his work covered advanced design on VISTOL aircraft and drones, study of astronaut escape systems from orbital vehicles, operations research, management science and R&D administration. It was in the aerospace industry that he gained appreciation of the importance of the aspect of man-machine interface.

Mr. Nishizaki joined the Transportation Development Centre in 1974 and is currently responsible for the management of the Transportation Systems Technology Division whose mandate includes research related to application of ergonomics in addition to the marine R&D program. His project portfolio includes the air traffic control work station and the automobile driving simulator.

ATELIER 4
POSTES DE TRAVAIL INFORMATISÉS

Facteurs ergonomiques à prendre en compte dans l'étude des terminaux à écran de visualisation

Président — R. Nishizaki,
Centre de développement des transports

M. Nishizaki est diplômé en génie mécanique l'Université de la Colombie-Britannique. Il est également titulaire d'un diplôme d'études supérieures en gestion de l'Université McGill. Il a oeuvré pendant toute sa carrière dans le domaine de la recherche et du développement, d'abord dans l'industrie aéronautique, puis au Centre de développement des transports de Transports Canada.

Il a amorcé sa carrière en 1956 à la Bristol Aircraft Limited de Bristol (Angleterre), à titre d'ingénieur d'étude et de mise au point d'hélicoptères. En 1959, il entre chez Canadair à Montréal, où il a travaillé dans les domaines suivants : conception avancée d'ADAC/ADAV et de véhicules guidés, étude de systèmes d'évacuation des engins spatiaux en détresse, recherche opérationnelle, sciences de la gestion et administration de R&D. Dans l'industrie aérospatiale, M. Nishizaki a été à même de saisir l'importance de la question des interfaces homme-machine.

M. Nishizaki est entré au Centre de développement des transports en 1974 où il est, à l'heure actuelle, en charge de la division Technologie des systèmes de transport dont le mandat comprend la recherche appliquée en ergonomie en plus du programme de R&D en transport maritime. Parmi les projets qu'il pilote personnellement figurent l'étude d'un nouveau poste de contrôle de la circulation aérienne et celle d'un simulateur de conduite automobile.

Air Traffic Control

P. Stager, York University

Dr. Paul Stager is Professor of Psychology, York University, and Consultant in Human Factors. Paul Stager has broad research and consulting experience in simulation techniques, performance and workload evaluation, and human information processing. As a licenced pilot, he has worked extensively with the Canadian Armed Forces and with both the Air Traffic Services Branch and the Canadian Coast Guard of Transport Canada. His primary concern in previous projects has been the assessment of the operational environment and its effect on task performance.

During the mid-1970's crisis in Canadian air traffic control (ATC) when the use of two languages was at issue, Paul was a member of the Transport Canada team which directed and evaluated the bilingual ATC simulation studies. His current projects include consultation with John Arnott and Associates in Toronto on the development and evaluation of a new air traffic controller work station and with Air Traffic Services on the analysis of operational irregularities. In addition, he is consulting with Ergo Systems Canada of Vancouver on the evaluation of alternative controls for telemanipulators in heavy equipment and with DCIEM in Toronto on the evaluation of an aircraft attitude display system.

Dr. Stager is a Past-President of the Human Factors Association of Canada and is currently the Canadian representative on the Executive Council of the International Ergonomics Association.

Introduction

The fact that ergonomics or human factors is a multi-disciplinary study has been apparent in the presentations today. Ergonomists or human factors specialists are often part of a program which is in turn multi-disciplinary. The development of large systems, for example, usually involves several disciplines such as engineering, industrial design, ergonomics or human factors. The following description of the development of a prototype for the new air traffic control work station (ATCWS) represents the application of ergonomics/human factors principles to the interface of the operator with a large, complex, and highly automated system.

The air traffic control system in Canada is about to undergo a fundamental change. Over a period of time, the current Flight Data Modernization Project (FDMP) will introduce a high degree of automation to the handling of ATC data. There are a number of implications associated with this automation for the kind of controller work station that is to be developed. The work station represents the controller/system interface and the qualities of the work station must reflect the automated system's powerful data processing capability.

The ATCWS was a project undertaken by the Arnott Design Group in Toronto and funded by the Transportation Development Centre, the Department of Supply and Services, and Transport Canada. The prototype work station was developed as a research vehicle that would enable researchers to explore a number of conceptual issues including the controllers' interaction with a very responsive electronic environment. A subsequent development model will be available for the refinement of concepts so there is much work to be done beyond that represented in the ATCWS prototype.

The Current ATC Environment

Within ATC, there are two major types of control environments: These are the non-radar or procedural control environment and the radar environment. Depending upon the geographical area involved, either of these control environments may occur for enroute traffic between centres. In the terminal area of the larger centres, however, radar control must be applied for

the orderly flow of traffic. For the purpose of assigning control responsibility, segments of the Canadian airspace are allocated to regional area control centres across the country. Within these larger segments, the airspace is again divided into sectors which may involve either radar or non-radar control.

Non-radar control depends on communications received from the aircraft. Most of the controller's work or information processing is based on the use of flight progress strips that are displayed on large strip boards. The paper flight strips have continued to be a primary information processing instrument in enroute control even as other sources of information for control have become available. One point to bear in mind (and one which has been alluded to in the other presentations) is that many of the control systems that we have now in transportation have evolved over a considerable period of time. The information that we have been able to provide to the operator has been increasing over the same period and frequently there is a situation in which the mode of presentation, the format, and the quality of information vary widely within the same work station. What we see taking place currently in many transportation systems is the redesign of the information displays and the operator interface so that the data required by the operator are presented in a more logical and integrated manner. This is particularly true, for example, in aircraft cockpit displays.

Radar control of enroute flights requires both flight progress data and radar displays that provide a plan view of the controllers' airspace. The different information displays that are available at a typical radar sector work station are illustrated in Figure 1. The displays include the JETS (Joint Enroute Terminal System) radar that has been in use for nearly ten years, and various auxiliary displays including weather, status information on facilities, arrival and departure sequences, and airway maps. Frequently, these graphic displays are not optimal in terms of legibility and brightness given the context of the other displays at the work station.

Figure 1 A typical controller work station in a radar sector.

A significant potential for error can arise when only one controller handles both the radar and the data positions in a standard radar sector. Although the radar sector work station may not be optimally designed for one controller, this practice is common for some sectors during periods of the day that have a lower volume of traffic.

Design Objectives for the ATC System

The development of a controller work station, including prototype graphics, requires the synthesis of a number of the controllers' existing displays, integrating them in a way that will facilitate information processing and decision making. In addition, there are certain assumptions or premises that have to be kept in mind during the course of developmental work. These might be called system guidelines and their description here draws significantly from discussions with David Hopkin of the Royal Air Force Institute of Aviation Medicine at Farnborough.

The first guideline is that in future systems, the controller will have to retain a central role. Too often in system design the operators have been encouraged to adapt to the system or to the environment. With the introduction of a high level of automation, there is the opportunity to have a system which is highly adaptable — one that can be adapted to the controller. In studies that have looked at computer aiding, however, it has been shown that under some circumstances the controllers can feel that they are being driven by the system. We have to design a system that has computer aiding but also a system in which the controller remains central and in control of the information processing.

A second guideline is that with automation of data handling we run the risk that if the controller is not actually doing some of the information processing in an active, hands-on, fashion, there may be a weakening of the memory function. Without a more comprehensive understanding of the current state of the system, the controller may lose what is referred to as the "picture". The highly automated system may have to provide a replacement for the information processing cues that the controllers have come to rely upon for updating their own memory systems and reprogramming their responses to system demands.

A third guideline is that professionals, such as air traffic controllers, take a certain pride in the application of their skills. The automated system that is now envisioned will have to provide opportunities that allow the controllers to maintain their skills and to demonstrate them to themselves as well as to others. The level of automation to be provided must not oversimplify the controllers' responsibilities in the sense of reducing the skills demanded.

The fourth guideline is that we have to promote what has been referred to as a symbiotic relationship between the controller and the control environment. When computers were first introduced for data processing in operational systems, the scientific literature spoke of there being a symbiosis between man and the computer. That concept may have been lost somewhere over the years but it is a concept that might be applied with good effect in current systems. The implications of a symbiotic relationship involving computer assistance includes the consequence that operators will retain the central role already alluded to and that they will not be dominated by the system. An equally important consequence is that in allocating functions to the human operator within an automated system, the functions need not be allocated in an exclusive way, that is to say that it is unnecessary to determine that the operator is more efficient in one function and that the computer is more efficient in another. Rather, we can look at the information processing and control functions as being accomplished in the system in an interactive and perhaps parallel mode where responsibility for certain functions may be interchanged depending upon momentary circumstances. In this context, the computer becomes a useful interactive tool through which the controllers are able to perform more effectively.

A fifth guideline is that air traffic control is a team activity and information that is provided to the controllers has to be viewed as information that is being provided concurrently to a team of participating decision makers. In the automated system, there is the likelihood that some of the controller communications or controller-pilot communications will be markedly reduced. We have to ensure that all members of the team, the controllers and the pilots, receive appropri-

ate and sufficient information to maintain a full comprehension of the activities and status of their control environment.

A final point is that if we think of the concepts of automation, computer assistance, and expert systems, there is the implication certainly in expert systems that there are a relatively small number of decision rules that may apply to a situation. One of the characteristics of the current air traffic control system that probably has kept the system functioning effectively is that controllers have had the option of solving problems in several ways. The requirement for problem solving as new situations arise is part of the controllers' professional activity and probably also a significant determinant of successful system performance. The characteristic of flexibility in problem solving is likely one that will have to be retained in future systems.

The Prototype Work Station

When the potential for system change exists, there is the question of just to what extent the system should be changed. How rapidly should it be changed? What supports have to be provided for the controllers during the period of change? In the case of the ATCWS, it was not too difficult to provide a radar presentation similar to the one that controllers are currently using or to provide an electronic display that enabled the controllers to work with flight strips that were very similar to what they are using now in a paper form. The proposed work station, however, will probably move beyond these electronic derivatives of existing technology and practices.

The work station that will eventually be put in place will probably use two raster displays and will be designed for optimal use by either one or two controllers. The prototype work station developed by the Arnott Design Group is shown in Figure 2. The prototype represents an integrated work environment that is based on two 19-inch colour displays.

Figure 2 Prototype air traffic control work station.

The radar display on the left screen makes use of low contrast and complementary colours presented on a high resolution raster display. The display is very easy to work with for the du-

ration of the controller's work schedule. The graphics that are used to represent the flight progress strips appear on the screen to the right. In this prototype, the flight strips can be revised with the use of the mouse as an interactive device. Changes made to flight information on either screen automatically appear on the display of the second screen. Instead of having auxiliary displays that are located at disparate points about the work station and that are variable from one to another in terms of legibility, contrast, and brightness, several displays have been integrated into one screen. For example, weather information or the status of different airports can be accessed through the use of windows on the radar display. In addition to various forms of the flight strips, the screen on the right can display airway maps and approach plates, and an innovative depiction of altitude and time separation between aircraft. There has been some exploration of generating radar graphics that enable the controller to view a section of airspace from different perspectives. However, there needs to be further research to determine the potential value of applying this type of display to air traffic control.

Developmental Research Requirements

As a result of the developmental work represented by the current prototype work station, several areas of focus for subsequent research have been identified.

One question to be investigated concerns the optimal input devices for the work station given the graphics development that can be expected to take place. Obviously, graphics will have to be developed and selected with reference to their impact on controller performance. A second proposed area of investigation represents a very important point: What is the optimal balance between standardizing the kinds of displays to which controllers have access while at the same time recognizing the need to allow the controllers to adapt the displays to their own skill level? Finally, a third area of research would recognize the need to explore the characteristics of the displays that are required to represent the diversity of control environments that exist in Canada and that arise in part from the tremendous geographical span and topographical variability within the Canadian ATC system.

There will be a significant and continuing opportunity for the application of human factors principles in addressing these three future areas of investigation as well as in the next development model itself.

Ergonomics Evaluation of Communicaid

Ruth M. Heron, Heron Ergonomics

Dr. Heron obtained a Master of Science in 1971 and the Ph.D. in 1975 from University of Calgary. Her career in transportation ergonomics began just after that in the Road Safety Branch where she carried out studies in impaired driving, the perception of traffic signs and rear-lighting configurations, driver education, and seat belt usage. For the next three years she was a professor at Queen's University, teaching ergonomics, communication, psychometrics, and advanced research methodology. Subsequently, heading up the Research and Statistics Department at the Alberta Workers' Compensation Board, she carried out a variety of ergonomic studies relating to injured workers. During this time, she continued her work in transportation ergonomics as a consultant for the Transportation Development Centre and later joined this group with a mandate to develop an ergonomics capacity within it. There, she initiated, developed, managed, and contributed ergonomics expertise to many projects involving the development of technology related to marine, air, surface, and rail transportation, and to transportation for the elderly and disabled. Currently she practises ergonomics through her own company, Heron Ergonomics, and is on the Board of Editors of the international journal, Specialized Transportation Planning and Practice. Recently she was elected to the Professional Register of the founding Ergonomics Society in the U.K.

My talk is about the ergonomics evaluation of the Mark I prototype of Communicaid, an automated information work station for communication-impaired travellers. I chose this particular topic and this particular example because it makes for a very good demonstration of how the ergonomist interfaces with the designer, and how information that has important economic advantages for the designer — and the developer — can be generated by an experienced ergonomist.

In an earlier study, we had observed numerous problems among sight-, hearing-, and speech-impaired subjects using existing communication devices in simulated scenarios in a transportation terminal. Communicaid, developed by TDC and designed by Uwe Rutenberg, was meant to overcome these problems. It is a system that allows the traveller with communication difficulties to interact with a computer in two ways: first, independently, in order to get information regarding services and facilities within the terminal and, also, in a dialogue with an agent in order to obtain help with flight arrangements that would be time-consuming and difficult to make at the ticket and check-in counters. Only the speech- and hearing-impaired need the dialogue function, as a sight-impaired person who can both hear and speak has no difficulty in two-way communication.

Figure 1 gives a view of the prototype as it was installed at Vancouver International Airport where the evaluation was carried out during Expo 86. The brightly coloured 'high-tech' appearance of the exterior is meant to attract the user, the symbols to inform him or her of the system's purpose. In Figure 2, a subject is seated at the traveller work station inside the kiosk. The diagrammatic view of the interior in Figure 3 shows the location of various parts of the system.

From these illustrations, it will be seen that Communicaid is a rather complex system involving a highly variable user population in different types of motor and cognitive tasks. To understand how an ergonomist might go about an ergonomics evaluation of it, we can start with the general purpose of the evaluation which, in this case, was to remove uncertainty about the form and function of the system before developing a production model. It is often the case with novel concepts like this that there is insufficient information to develop a Mark I prototype that is ergonomically suitable in every sense. And so the iterative approach is taken, getting a somewhat rudimentary prototype out in the field and gathering data necessary for decisions about further development.

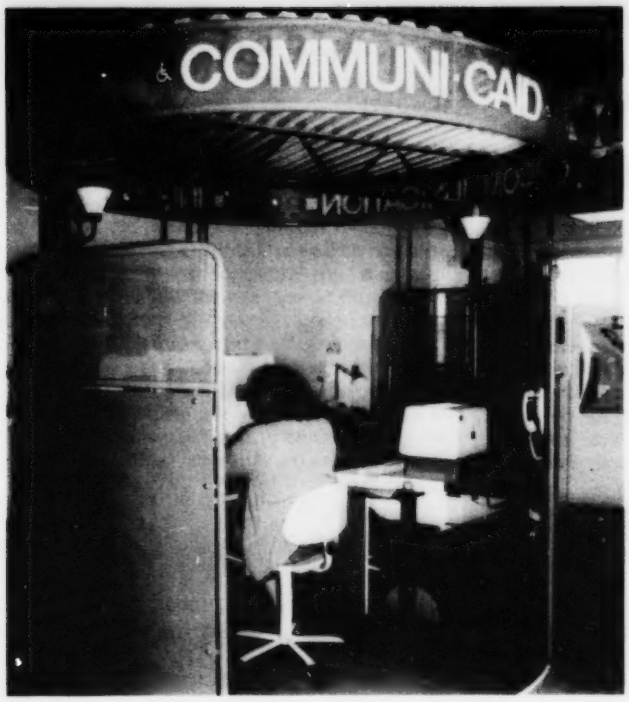


Figure 1 An exterior view of Communicaid.

Figure 2 An interior view, showing a traveller operating the work station.

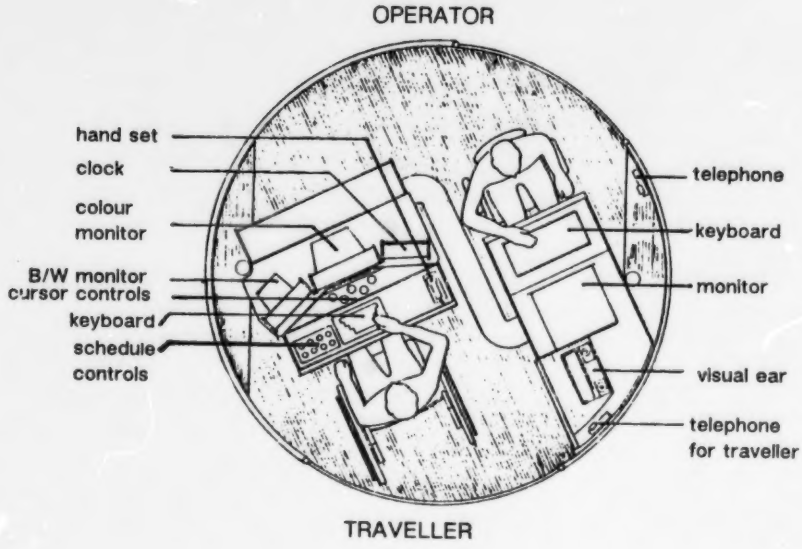


Figure 3 A diagrammatic view of Communicaid, with certain components labelled.

For this particular evaluation, two analytical approaches were combined, namely, systems analysis and task analysis, the first of which is well known to engineers. It consists simply of, first, breaking the system down into major components, groups of components, or subsystems, and then breaking each of these into smaller and smaller units until a good engineering analysis is possible. In an ergonomics evaluation, a similar procedure would be followed. However, as the aspects focussed on are person/system interactions, the breakdown of system components would need to be done in a way that allows these interactions to surface and be analyzed. To obtain this result for the evaluation of Communicaid, one of the many forms of task analysis was combined with the systems analysis.

As a lead into how this was done, let us consider first the major subsystems isolated for the Communicaid evaluation: the exterior, the interior layout, the system for the hearing- and speech-impaired, the system for the sight-impaired, and the system for the agent. One of these, say, the system for the hearing- and speech-impaired, can be used to show how task activities and processes were brought in to the picture. Its major components appear in Table 1, the corresponding major tasks in Table 2.

Table 1
Major Components of Hearing- and Speech-Impaired Subsystem

— colour monitor
— screens: instruction, menu, information, map, and dialogue
— cursor pad
— simplified Qwerty keyboard
— laser printer and slot
— printout
— monochromatic monitor
— airlines schedules screens
— controls for monochromatic monitor

Table 2
Major Tasks for Hearing- and Speech-Impaired Subsystem

— manipulate controls
— read screen text
— access information
— communicate in dialogue with agent

Once the major components of the subsystem had been identified along with the major tasks associated with those components, design of the evaluation protocols could proceed. There are two aims in administering the protocols in an evaluation of this kind of system, namely, (a) to pinpoint system features violating operators' sensory, perceptual, cognitive, motor, and psychological limitations (and/or not capitalizing on their capabilities in these areas), and (b) to determine the nature of modifications required to make the system ergonomically sound. Accordingly it was necessary to break down each of the system components into features small enough that a simple function could be established for it, and so that all the user/operator task activities and processes associated with that function could be identified. Then a recording sheet could be designed that incorporated all this information and, thus, serve to guide the evaluator during the task observations.

The procedures just described represent one part of an ergonomics evaluation of this kind, for which the formal scientific knowledge of the ergonomist comes importantly into play, along with the experience he or she has had in developing and carrying out evaluations for use by engineers and industrial designers. In the interest of efficiency, safety, and economy, any system that involves complex inputs to the brain needs to be evaluated by some one who has not only extensive knowledge of how those inputs are handled by the brain, but also expertise in teasing out problems that occur during these processes because of system design deficiencies.

Figure 4 gives an idea of the recording protocol for one of the hearing- and speech-impaired subsystem features, the main menu. From this, we see that the function of the main menu is to inform the traveller regarding the categories of information available, and to allow him/her the choice of selecting a category, returning to the previous screen, returning to the introduction, or ending the session. The user activities and/or processes associated with this function

are the perceptual processes of detecting, recognizing, discriminating, and interpreting letters and words on the screen. The user must also store some of the information in short-term memory, make a decision regarding the various options open to him/her and, accordingly, either exert a control response of moving the cursor and pressing the hit button, or leave the kiosk. The protocol booklet contained a recording sheet like this for each system feature. There was space on each for observed problems, recommendations, and explanatory comments.

After all the observations were made, the data were of course analyzed and synthesized and then set up in a document in which each feature has a sheet with the same format as its recording sheet counterpart. Figure 5, showing the notations that were recorded as problems with the main menu, gives a flavour of the economic form in which the engineer and the developer receive outcomes of the evaluation. It is clear from this figure that a great deal

Feature	— main menu (screen 0.1)
Function	— inform re information categories — allow choice re select category/return previous screen/return intro/end session
User Activities/ Processes	— detect, recognize, discriminate, interpret letters/words — store items in short term memory — decide re category/previous screen/intro/end — move cursor, press hit
Problems	
Recommendations	
Comments	

Figure 4
Recording protocol for main menu feature

Feature	— main menu (screen 0.1)
Function	—
User Activities/ Processes	—
Problems	— return to intro too fast for decision — no agent-assistance option until select from menu 0.1 — phrasing of options inconsistent screen-to-screen — poor readability — mental load high — screen density too high — character dimensions nonoptimal — spacing of words nonoptimal — formatting impedes fast perceptual organization — contrast not high enough for partially sighted

Figure 5
Excerpt from evaluation document, showing problem notations

needed to be done to the main menu screen to maximize the rate at which the information it contains is transmitted to the user. However the recommendations appearing on the remainder of the document in the same economic form are explicit with respect to the nature of system modification required to remove each problem, and are accompanied by illustrations of how the extremely important process of perceptual organization can be achieved on the screen in question. The point of this talk was to demonstrate one way in which an ergonomist works with designers. But perhaps it should be said also that a good ergonomist is one who understands that one of the points of carrying out an evaluation of this sort is to make life easy for the designer and the developer. They, after all, are the ones who must make the development decisions. The methodology I have described is systematic, comprehensive, and sensitive in small detail to design defects of the kind that might affect the marketability of the product because they exceed limitations of the human sensory, brain, motor, or psychological systems. Accordingly it provides information that cannot be obtained from reports of users who, as Leslie Buck mentioned earlier, may know that something is wrong for them about a system but not either why it is wrong or the best way of correcting it. The provision of this precise information in a concise explicit form fills this gap, aiding the designer in decisions regarding modification or reconceptualization of the system, and the developer in those regarding whether or not to proceed toward a production model.

PANEL/AUDIENCE DISCUSSION

Chairperson — Dr. R. Kruk,
CAE Electronics Ltd.

Dr. Kruk served as a pilot in the Canadian Forces in the late 60's and 70's both in aircraft and helicopters. He then turned his attention to the study of human vision and performance and obtained a Ph.D. in psychology in 1983 specializing in visual psychophysics. Since 1983 he has been involved in the development of advanced technology products at CAE Electronics in Montreal, particularly in fibre optics, helmet-mounted display, and multi-axis, single-hand controller. Currently he leads the human factors research and development group at CAE.

DÉBAT-DISCUSSION

Président — Dr R. Kruk,
CAE Electronics Ltd.

R. Kruk a été pilote d'avion et d'hélicoptère dans les Forces armées canadiennes à la fin des années 60 et dans les années 70. Par la suite, il s'est intéressé à l'étude de la vision humaine et des performances visuelles, obtenant un doctorat en psychologie en 1983 : son champ de spécialisation était la psychophysique de la vue. Depuis 1983, il a participé à la mise au point de produits de technologie avancée chez CAE Electronics de Montréal, en particulier dans le domaine de fibres optiques, des visuels de casque et des commandes multi-axes à une seule main. À l'heure actuelle, il dirige le groupe de recherche et de développement en ergonomie de cette même société.

Opening Remarks — Dr. R. Kruk

Thank you. Well it's late in the day and it's been a long day, so we're going to try to do this in a fairly brief fashion. Ruth Heron suggested that we start this session with a one-minute summary from each of the session chairs as to what they felt they might have learned from their own sessions, emphasizing any particular point. I think I'd like to do that. I'll give the chairs a few minutes to think about what they're going to say, and I'll lead off the whole thing with my own impressions of today. For those of you here who are not ergonomists or human factors specialists or psychologists I think what you've seen is a day long session introducing you to all of the good stuff that good ergonomic design can do for you. It'll improve the acceptability to the consumer of your system or your product, it'll improve product safety, it'll improve the performance of the operators, and we've had a number of presentations indicating specific ways that ergonomics might be applied to certain kinds of product lines or systems. So it's good for you. Cod liver oil is good for you too and so is an after dinner liqueur. One of the things I'd like to hear from the transportation managers here is in your experience, to date, have your encounters with ergonomists or human factors specialists been cod liver oil or an after dinner liqueur? Specifically, have you found difficulty finding these people? Do you have difficulty determining what sort of qualifications they should have to do the kind of job that you want them to do? Do you have difficulty getting them to stick to schedules? How much did they cost? Where do you find them? So I'd like part of this discussion this afternoon to really come back from the transportation managers here. What has your experience been? Or have you had any experience at all with what is, in most environments, a consulting service to design staff or to engineers? So I'll leave you with that and go back to the session chairs.

I'm starting in order of presentation throughout the day. David Lewis.

Ouverture — Dr R. Kruk

Merci. Il est déjà tard et la journée a été longue. Nous nous efforcerons donc de faire vite. Ruth Heron avait suggéré de commencer ce débat-discussion par un rappel succinct (une minute), par les quatre présidents d'atelier, de ce qui a été dit durant leur atelier respectif, surtout les faits saillants. Je pense que c'est une excellente idée. Je vais d'abord vous faire part de mes impressions personnelles, ce qui donnera aux intervenants le temps de se préparer. Pour ceux et celles d'entre vous qui ne sont ni des ergomistes ni des psychologues, vous avez eu l'occasion d'apprendre aujourd'hui ce que l'ergonomie peut faire pour vous: relever l'intérêt des consommateurs pour vos produits, améliorer la sûreté de ceux-ci et accroître la productivité de ceux qui les utilisent. Un certain nombre d'exposés ont traité justement des méthodes que l'ergonomie peut mettre en oeuvre à l'égard de certains produits ou systèmes. Donc, c'est une bonne chose; tout comme l'huile de foie de morue et le pousse-café. Ce que j'aimerais entendre de la part des spécialistes des transports ici présents, c'est s'ils ont tendance à assimiler l'expérience qu'ils ont eue avec des ergonomistes à l'huile de foie de morue ou plutôt au pousse-café. Et plus particulièrement, s'ils ont eu de la difficulté à les dénicher? À déterminer les qualifications particulières nécessaires pour répondre aux exigences de la tâche attendue d'eux? À leur faire respecter les délais impartis? À savoir combien leur intervention coûterait? Donc, je demande la participation active des spécialistes des transports présents. Quelle est votre opinion de l'ergonomie? Quelle a été votre expérience avec des personnes qui, la plupart du temps, agissent à titre de consultants auprès des bureaux d'études ou des bureaux techniques. Sur ce, je cède la parole aux présidents d'atelier.

Commençons dans l'ordre des séances de la journée. Voici donc M. David Lewis.

Panelists' Comments

(David Lewis)

Thank you. I'd just like to make three points which represent general impressions that I drew from the day's discussion and presentation. The first, and speaking from the point of view of my discipline which is economics, I have been struck by the obvious and quite sizable value of ergonomic research in terms of its potential contribution to resource savings in the economy. The work that I heard described today will bring with it obvious and measurable economic savings in terms of reductions of fatalities and safety, and improved safety generally. It will bring about, too, an improved productivity throughout the economy, in air traffic control, in driver performance and other areas. In terms of time savings, and time is a very valuable economic resource with very measurable value, I see ergonomic research contributing to enormous time savings — to the general freedom from the irritation of poor design in society which brings its own very measurable, if somewhat intangible, benefits for us as individuals. So that's point one.

Point two, somewhat different, is the relationship that I perceive between ergonomic research, applied research, and the problem of responding to an aging society. We had a lot of discussion about design which had obvious bearings on age, sort of micro oriented studies, but I'm referring here to the more macro oriented policy implications of ergonomics. I hope that the ergonomists are becoming, or weaving their way into the policy circles of government. By way of example we heard a lot about signage and vehicle design. I was struck with the question, what about highway design generally? As we become an older society are we going to have to change the design for camber in roads? For the standards for the curvature in roads?

Commentaires des participants

(David Lewis)

Merci. D'abord trois points qui résument mes impressions personnelles de l'atelier que j'ai présidé. Premièrement, et du point de vue strictement économique, puisque je suis économiste, j'ai été frappé par l'apport évident et impressionnant de la recherche ergonomique et son utilité lorsqu'il s'agit des moyens à prendre pour économiser les ressources. L'exposé que j'ai entendu aujourd'hui montre les avantages économiques évidents et mesurables que l'ergonomie permet d'obtenir en réduisant le nombre de décès et en relevant de façon générale la sécurité. En même temps, elle accroît la productivité générale, quel que soit le domaine visé: contrôle de la circulation aérienne, camionnage et transports urbains, etc. Le temps étant une ressource économique très précieuse dont la valeur peut être mesurée avec précision, je suis d'avis que la recherche ergonomique apportera d'importantes économies à ce chapitre, si ce n'est par l'élimination des pertes de temps attribuables à un produit mal conçu; économies donc, dont les avantages cumulatifs sont tout à fait mesurables même s'ils sont a priori quelque peu imperceptibles. Voici pour le premier point.

Deuxièmement, partant d'un point de vue totalement différent, je relève le rapport qui semble exister entre la recherche ergonomique, la recherche appliquée et le vieillissement de notre société. Il a beaucoup été question de conception et des relations, évidentes avec l'âge toujours dans un contexte spécifique, de cas d'espèce en somme. Mais ce à quoi je fais allusion ici, ce sont les conséquences macro-analytiques de l'ergonomie. J'espère que les ergonomistes sont en train de pénétrer les milieux gouvernementaux chargés de l'élaboration des politiques. À titre d'exemple, on a parlé de signalisation et de conception de véhicules. J'ai été frappé par cette idée: qu'en est-il de la conception des routes

For lane widths? For visual distance standards generally? Roads have 20 or 30 design lives. It seems to me that ergonomists should be contributing now to the design requirements of roads in 20 to 40 years from now.

elles-mêmes? À mesure que notre société vieillit, serons-nous amenés à modifier le dévers et la courbure de nos routes, la largeur des voies, les distances de visibilité en général? La durée de vie théorique des routes est généralement de 20 à 30 ans. Il me semble que les ergonomistes devraient commencer à s'intéresser aux critères de conception des routes qui seront construites dans 20 ou 40 ans.

And finally, my final point. I hope we'll draw some discussion because I could be quite wrong, in deference to Dr. Ruth Heron, who is far more the quantitative analyst than myself, I would still offer the following observation that drawing upon so many disciplines as ergonomics does, it seems that it's difficult to establish a scientific standard of research. We heard some debate this morning about the major railway disaster. We heard debate about the various factors that might or might not have contributed to it: health, alcoholism, sleep and so on. It seemed to me that that kind of argument is subject to resolution through standard multivariate statistical methods which are no doubt being applied in parts of the field, but my sense was that they're not being applied in other parts of the field. And I wonder if, as this young science grows, some attention is needed to the development of scientific standards of research and presentation. That's it, thank you.

Enfin, pour terminer, j'espère que la discussion éclairera ce point, parce que je peux être dans l'erreur. Sauf le respect que je dois à Madame Ruth Heron, qui est de loin plus compétente que moi en analyses quantitatives, je pense que, étant donné que l'ergonomie fait appel à un si grand nombre de disciplines, la mise en place d'une norme scientifique de recherche se révélerait difficile. Il a été question ce matin d'un grand accident ferroviaire et des nombreux facteurs qui ont pu ou non y contribuer tels que: état de santé, alcoolisme, sommeil, etc. Il m'a semblé que ce genre de problème pouvait être résolu par les méthodes classiques d'analyse statistique multidimensionnelle qui, sans doute, sont utilisées dans certaines disciplines ergonomiques mais qui, d'après moi, ne le sont pas dans d'autres. Et je me demande si, à mesure que cette jeune science se développe, il y aurait lieu de penser à l'élaboration de normes scientifiques de recherche et de présentation. C'est tout, merci.

(Pat Hallett)

(Pat Hallett)

Thank you. Interesting to follow David on that because I have some of the same sort of observations. At the risk of appearing insulting, but not wanting to be insulting, Ruth, we're going to use you as an example again. I go back to about 1974, I believe, when we first crossed paths in the Road Safety group and I think I was exposed to some of the human factors work being proposed at that time. I recall Ruth Heron doing a paper for a group called RTAC (some of you may be familiar with the Roads and

Merci. C'est intéressant ce que David vient de dire parce que j'ai pu faire moi-même quelques-unes de ces observations. Au risque de paraître insolent, mais sans vouloir l'être le moins du monde, Ruth, nous allons encore nous servir de vous comme exemple. C'est vers 1974, je crois, que nous nous sommes rencontrés, Ruth et moi, au sein du Groupe de la sécurité routière où j'ai pris connaissance pour la première fois de certains travaux ergonomiques proposés à l'époque. Je me rappelle l'exposé que

Transportation Association of Canada, certainly Bob Dewar is). One of the key areas that they were looking at was the whole thing on signing, and Ruth passed her paper to me for review since she knew that I had some exposure to this group; and my problem at that time was that I couldn't understand what she was saying. She had a lot of interesting terminologies and so on. What strikes me, at this point in time, is that I think we've come an awful long way, in terms of the understanding in both directions. The human factors specialists and psychologists and ergonomists and so on, are speaking in a terminology and a language that I think has become a lot more understandable, a lot more acceptable. And I think by some of the questions and receptivity by the engineering and industrial designers and so on, I think they have come a fair way as well to try and understand that discipline and understand how it's applied to the systems that they're struggling with either in an operational sense or a new design sense. So I think the understanding gap has closed dramatically. I do also share what David was commenting on. I think this issue of performance standards and trying to push that into the human factors area. One of the key pitfalls, I think, are the issues of test methods. Inevitably as you want to have these standards, you have to have a method that is accepted as a test bench mark and until that is nailed down and has proven 99.9 percent reliability these methods do tend to be debated very much in a research community in terms of controls and whether you've tested systematically and so on. Control noise and so on in the system.

I was also struck by Dr. Smiley's comment to me, probably not during her presentation but separately, where she was especially pleased that the real problems of ergonomics were taken seriously in the commission enquiry on the Hinton train disaster, and that they did embrace most, if not all of the recommendations. So there is being established a credibility that probably wasn't there as few as three and four and five years ago. The final aspect that essentially

Ruth Heron avait fait devant un groupe appelé ARTC (certains d'entre vous connaissent certainement l'Association des routes et transports du Canada, n'est-ce pas Bob Dewar?). Un des grands secteurs de recherche alors était celui de la signalisation et Ruth m'avait remis le texte de son exposé pour que j'y jette un coup d'oeil, sachant que je connaissais déjà ce groupe; et je me rappelle que je ne comprenais pas grand-chose de ce qu'elle disait. Sa terminologie était intéressante, c'est vrai. Ce qui me frappe aujourd'hui, c'est tout le chemin parcouru, depuis, dans la compréhension mutuelle. Psychologues et ergonomistes utilisent une terminologie et un langage qui, je crois, sont devenus plus compréhensibles et plus acceptés qu'alors. Et je crois, d'après certaines questions et l'attitude des ingénieurs, des concepteurs industriels et d'autres, qu'ils ont fait du chemin vers la compréhension de ce que cette science veut accomplir et comment elle peut être appliquée aux systèmes dont ils ont la charge sur le plan soit de la conception, soit de l'exploitation. À mon avis, le fossé de l'incompréhension mutuelle s'est drôlement comblé. Et je partage les vues de David sur la question des normes de performances et sur la volonté de les faire intervenir dans le domaine de l'ergonomie. Un des grands pièges à mon avis est la question des méthodes de contrôle. Inévitablement, qui dit normes dit méthode universelle. Or, jusqu'à ce qu'elle ait été mise au point et que sa fiabilité ait été prouvée à 99,9 p. 100, on ne finira pas d'en débattre ainsi que des contrôles à mettre en place, de la systématisation des modes prératoires et ainsi de suite. En somme, de tout ce qui peut parasiter le système.

J'ai également été frappé par les remarques que le Dr Smiley m'a adressées non pas durant son exposé, mais ailleurs, à propos de la satisfaction qu'elle éprouvait du fait que les vrais problèmes ergonomiques avaient été pris au sérieux par la commission d'enquête sur l'accident ferroviaire de Hinton et que celle-ci avait adopté la plupart des recommandations, sinon toutes. Il existe donc une crédibilité qui n'existait pas il y a trois, quatre ou cinq ans de cela. Un dernier

ties into the understanding gap is that the application of these methods and these techniques in the real world, if you will, of transportation issues and problems, as evidenced in my particular workshop on transportation safety, has certainly gone a long way to try and rationalize the issue of the human operating in the machine or with the machine in a certain environment that might be changing. As Bob mentioned in his presentation, a dynamic not a static or ecstatic system of doing the driving task, is one example. So my observations are similar to David's in terms of the concerns about science, in terms of the rigorousnous that can be applied and accepted especially if we try to move it into performance type of standards. But I would also like to observe that it's come a long way on that understanding gap, when I go back to discussions in 1974.

(France Legault)

Thank you. I will try to put into perspective human factors as engineers tend to view ergonomics. During my session we saw how intelligent displays and visual displays interact with humans, in a very informative way. We saw how visual displays can have both assets and liabilities, depending on how they are applied, and this is where I think human factors specialists come into play and are very important. The second point I'd like to stress is that human factors specialists should be called in to work on multi-disciplinary teams to develop effectively a system in which people and machines can interact effectively. I think, as Ian has pointed out, that visual displays have come a long way in vehicles since 1978 when they were seen more as a toy for the person who would order everything that could be ordered in a vehicle, and they've moved now more towards a useful information system. More and more the combination of intelligent systems and analogue displays are coming into light. I was very glad to see that Dr. Ells was called in from the start to help a team

point qui, au fond, se rattache au fossé de l'incompréhension mutuelle est que l'application de ces méthodes et techniques au monde réel des transports, comme j'ai pu le constater dans l'atelier que j'ai présidé sur l'ergonomie et la sécurité, a permis de faire un grand pas vers l'objectivation de l'élément humain dans tout système homme-machine, ou travaillant avec une machine dans un environnement en évolution. Comme l'a dit Bob dans son exposé, la mise en évidence du caractère variable et non pas immuable de la tâche de conduire en est un exemple. Donc, mes observations se rapprochent de celles de David relativement aux questions que notre science se pose, à savoir la rigueur qui peut être appliquée et acceptée, surtout lorsqu'on essaye de faire intervenir les normes de performances. Mais je voudrais ajouter que, par rapport aux débats de 1974, un grand chemin a été parcouru vers une compréhension mutuelle.

(France Legault)

Merci. Je vais essayer de mettre en perspective les facteurs humains, comment les ingénieurs ont tendance à envisager l'ergonomie. Durant l'atelier que j'ai présidé, j'ai pu constater par quel moyen des visualisations intelligentes peuvent avoir des interactions avec l'être humain; c'était très instructif. Nous avons également constaté comment ces visualisations peuvent avoir de bons et de mauvais effets, selon l'utilisation qui en est faite et c'est là, à mon avis, que les spécialistes des facteurs humains peuvent intervenir et jouer un rôle déterminant. Le deuxième point que j'aimerais souligner est que ces spécialistes devraient faire partie de toute équipe multidisciplinaire, et travailler à la mise au point d'un système où les interactions hommes-machines peuvent se faire efficacement. J'estime, comme l'a dit Ian, que beaucoup de progrès a été fait dans les tableaux de bord des véhicules depuis 1978, alors qu'ils étaient considérés comme des gadgets servant à appâter le consommateur. Ils se sont maintenant transformés en systèmes d'informa-

design a system rather than be called in towards the end to evaluate ergonomically the Star Vue system. I think this is moving towards the right direction. And the last point I'd like to make is that we engineering types, if we've learned only one thing today, I hope it's going to be that human factors is a science that experts should be called in to work on. Thank you.

(Roy Nishizaki)

In my session you saw how ergonomics plays a role in the improvement of the safety and efficiency in the movement of people within our transportation system. I think a lot of us who travel by air are concerned about the question of air safety and here we saw an example of how ergonomics is being applied to reduce the overload on the hard-working air traffic controllers. There's another sector of the travelling public, the elderly and disabled, they have had problems in the past in accessing the present transportation system but we now see that, with improvements in the information system, we are able to provide them with the information necessary to make their travelling much easier. It not only helps them, but it also helps all the other travellers. So, just in summarizing, I think we're improving both the safety and efficiency of our transportation system through ergonomics. Thank you.

(Ron Kruk)

I suppose the main points that have been raised in the past few minutes are essentially that the field of human factors is gaining credibility, and has gained considerable credibility over the last few years, but that occasions where human factors personnel are involved early on in design decisions or the design process are, for most new products, still relatively rare. It tends to be a

tion très utiles. De plus en plus, des systèmes intelligents sont combinés avec des affichages analogiques. J'ai été contente d'apprendre que le Dr Ells avait été appelé à intervenir dès le début au sein de l'équipe chargée d'étudier le système Star-Vue, plutôt que trop tard pour donner le point de vue ergonomique. C'est un pas dans la bonne direction, à mon avis. Enfin, j'espère que nous, ingénieurs, aurons appris au moins une chose aujourd'hui, c'est-à-dire que l'ergonomie est une science à laquelle nous devons faire appel. Merci.

(Roy Nishizaki)

L'atelier que j'ai présidé a permis de constater comment l'ergonomie peut relever la sécurité et l'efficacité des systèmes de transport de personnes dans notre réseau. Je pense que tous ceux parmi nous qui voyagent en avion se posent la question sur la sécurité des transports aériens, et nous avons pu voir un exemple de la manière dont l'ergonomie est utilisée pour réduire la surcharge mentale qui écrase nos contrôleurs de la circulation aérienne. Il y a aussi une catégorie de voyageurs, les personnes âgées et les handicapés, qui depuis longtemps éprouvent des difficultés à prendre les transports en commun. Maintenant, nous pouvons améliorer leur sort grâce aux systèmes d'information qui rendent leurs déplacements plus faciles. Ces systèmes sont utiles à tous les voyageurs, et pas seulement aux handicapés. Bref, j'estime que grâce à l'ergonomie, nous sommes en train de relever la sécurité et l'efficacité de notre réseau de transports.

(Ron Kruk)

Si j'ai bien saisi les principaux arguments présentés ces dernières minutes, ils tendent, au fond, à montrer que l'ergonomie a gagné en crédibilité ces dernières années, mais que les occasions où il a été fait appel à des ergonomistes tôt dans le projet ou dans le processus de décision concernant un produit nouveau ont été plutôt rares. On fait appel à eux pour tenter de remédier aux

matter of attempting to reduce deficiencies that already exist in the design (that are in hardware, or the drawings are there and the design is frozen) or of finding some sort of data that will support the design position that's been taken. However, by and large, the situation is improving, at least from the standpoint of how we human factors professionals see it. Again, though, as I stated at the beginning of this session, the primary interest is how the people who are not human factors professionals in this room perceive the status of the profession and what they'd like to see coming out of it. So I throw it open to the floor.

(Marc Brenckmann)

I would like to take on your challenge and maybe switch metaphors. I don't see too readily how I can relate to medicine or after dinner drinks, but I was thinking of a wrench. I was party to the introduction of quite a number of ergonomics oriented projects at TDC and I can say that with the experience of these first attempts at TDC I came to the position that this was definitely one wrench that fitted certain fairly tight and obstinate nuts that didn't want to kind of be undone, problems to resolve. Now it is a wrench that unblocks the reluctant nut, but it is not quite yet the air wrench that Canadian Tire use to quickly dismantle the wheels of the vehicles to change tires. So it certainly has proven that it does address a problem. My impression, to date, has been that it is at the starting point and we haven't yet seen the full end result and the full benefits that can be obtained. Thank you.

(Ron Kruk)

I bow to a far superior metaphor.

faiblesses qui existent déjà dans la solution retenue alors que le concept a été "gelé", ou bien de trouver des données qui viendraient à l'appui de la solution retenue. N'empêche que grosso modo, la situation s'améliore, du moins du point de vue des ergonomistes. Là encore, comme je l'ai dit au début, la question primordiale est de savoir comment ceux parmi nous qui ne sont pas des ergonomistes perçoivent l'ergonomie et ce qu'ils pensent pouvoir en tirer. J'espère que le débat nous éclairera là-dessus.

(Marc Brenckmann)

Je voudrais relever votre défi, en changeant peut-être de métaphore. J'ai un peu de difficulté à me rattacher à l'alternative médicament/pousse-café que vous proposiez: j'assimilerais plutôt l'ergonomie à une clé anglaise. J'ai participé à l'élaboration de plusieurs projets à orientation ergonomique au CDT et j'en suis arrivé à penser que l'ergonomie se compare à une clé anglaise du fait qu'elle permet de mieux cerner ou appréhender les problèmes en quête de solution, au même titre que la clé anglaise qui s'adapte à la forme des écrous pour mieux les desserrer. Mais, bien qu'elle soit une clé qui desserre l'écrou récalcitrant, elle n'est quand même pas encore la clé à chocs qu'on utilise chez Canadian Tire pour enlever rapidement les roues des véhicules dont on veut changer les pneus. L'ergonomie sait certainement comment aborder un problème. Mon impression, pour le moment, est qu'elle en est à ses débuts et que nous n'avons pas encore vu tout ce qu'elle est capable de faire ni tous les avantages que l'on peut en tirer. Merci.

(Ron Kruk)

Je m'incline devant une métaphore supérieure à la mienne.

(Bob Radford)

Bob Radford from Canadian National. I'll step up as an acclaimed obstinate nut as you referred to. I mentioned to a companion, only half in jest, that your society perhaps should adopt as a song "I brought my harp to the party but nobody asked me to play", and I was thinking of some of the remarks to do with the Hinton accident and the discussion in other places. Although many factors are put forward, nobody at the end of it knows really the cause of the accident, and yet we are ready to apply cures in any number of directions. I believe that is, to some extent, jumping to conclusions. A lot of things are said about the factors in the locomotive, and yet those factors have improved considerably over the years and the locomotives that were involved, to my mind, although they were not designed with a professional ergonomist, were designed with a lot of thought to the working conditions. And I'm certain they're an improvement over the majority of locomotives that work in North America. I will claim progress is made and no doubt it will be disputed.

(Ron Kruk)

Is there anyone here that would like to address that comment?

(David Lewis)

I share your concern and tried to express a similar point in the second point I mentioned a few minutes ago. Let me use not so much a metaphor as perhaps an analogy and that's the work over the last couple of decades in the determination of a relationship between cigarette smoking and cancer. Even today I'm right in claiming that, in stating that the proof of cigarette smoking's causal link to cancer is less symptomalogical research, less based on symptomalogical

(Bob Radford)

Je m'appelle Bob Radford et je travaille pour le Canadian National. Je me présente comme l'écrou récalcitrant dont il a été question. J'ai dit à un collègue, un peu ironiquement peut-être, que votre association devrait adopter la devise suivante: "J'ai apporté de quoi chanter mais personne ne me l'a demandé." Je faisais allusion à certaines remarques touchant l'accident ferroviaire de Hinton et à d'autres débats. Bien que plusieurs facteurs aient été dégagés, personne ne sait encore la vraie cause de l'accident. Et pourtant nous sommes prêts à proposer des remèdes de toutes sortes. Cela s'appelle tirer des conclusions hâtives. On a dit un tas de choses à propos des locomotives et des facteurs en jeu; pourtant, ces facteurs ont été considérablement améliorés au fil des ans et les locomotives impliquées dans l'accident, bien que n'ayant pas été conçues par un ergonomiste de profession, l'ont été avec l'idée des conditions de travail bien en tête. Et je suis sûr qu'elles sont meilleures que la plupart des locomotives en service en Amérique du Nord. Je dis qu'il y a eu progrès mais, bien sûr, on ne sera pas d'accord avec moi.

(Ron Kruk)

Y a-t-il quelqu'un qui voudrait répondre à ce commentaire?

(David Lewis)

Je comprends votre inquiétude et j'ai tenté de l'exprimer dans le deuxième point que j'ai évoqué tout à l'heure. Permettez-moi de me servir moins d'une métaphore que d'une analogie. Je pense aux travaux faits au cours des deux dernières décennies dans le dessein d'établir un lien entre le cancer et le tabagisme. Même aujourd'hui, j'ai raison de dire, d'affirmer, que la preuve du lien causal entre le tabagisme et le cancer peut être établie moins par la recherche sympto-

evidence and more based in sound statistical multivariate evidence based on symptomatological data, empirical data. That was a hard nut to crack, but I suggest perhaps harder than the determination of the cause of a railway accident such as the Hinton accident based on the various factors or given the various variables that we were exposed to today. So it seems to me that the kind of data that we need, cross sectional data that we need, is available in our accident data banks, looking at various accidents and looking at data for individual accidents. And I wonder if the next phase in addressing the problem that you've raised isn't getting into the higher order of data analysis.

matologique, en quête de preuves symptomatologiques, que par des méthodes statistiques multidimensionnelles saines fondées sur des données symptomatologiques, c'est-à-dire empiriques. Cela n'a pas été sans peine plus, en tout cas, que de déterminer la cause d'un accident ferroviaire comme celui de Hinton, à partir des divers facteurs en présence, ou au vu des nombreuses variables dont il a été question aujourd'hui. Il m'apparaît donc que la sorte d'information dont on a besoin pour faire les recoupements nécessaires, se trouve déjà dans nos banques de données sur les accidents, qu'il suffirait de dépouiller. Et je me demande si l'étape suivante vers la solution du problème que vous avez soulevé ne serait pas de passer à un ordre supérieur d'analyse des données.

(Bob Radford)

(Bob Radford)

I wouldn't want to downplay the tragedy of the accident which is there and must be faced, but there are many people working with those conditions of tiredness and in those conditions of cab environment and it is yet almost a unique incident so I don't think that it's fair or correct to spread the blame quite so widely as tends to be done.

Je ne voudrais pas minimiser les conséquences tragiques de l'accident dont il est question et qui sont inéluctables, mais nombreuses sont les personnes travaillant dans les mêmes conditions de fatigue et dans le même environnement que celui du poste de conduite et, pourtant, cet accident est unique. Aussi, j'estime injuste ou incorrect de vouloir répartir le blâme aussi largement qu'on cherche à le faire.

(Ron Kruk)

(Ron Kruk)

Is it possible to phrase a comment?

Y aurait-il quelqu'un pour répondre à cela?

(Dan Buckingham)

(Dan Buckingham)

I find I can stand on both sides of the fence, both having hired ergonomists and now trying to sell one and I'd like to share with you just a bit of information which I think is a bridge between two sides. In 1980 I was hired by Ontario Hydro and stayed with them for four years trying to be this ergonomist. And during this period, sometimes once a month and as many as fifteen times a year,

J'estime être des deux côtés de la barrière, ayant engagé des ergonomistes et tentant aujourd'hui d'en promouvoir un, et je voudrais vous transmettre une information qui, je le crois, jettera un pont entre les deux positions. En 1980, j'ai été engagé par Hydro Ontario à titre d'ergonomiste, et j'y suis resté quatre ans. Durant ce temps, tous les mois et même jusqu'à 15 fois par an,

we went out and investigated fatalities of linemen. Somewhere between 10 and 15 men would die a year in electrical contact accidents. We were able through a lot of sophisticated programs to identify the presence of inclement weather. We were able to identify breaches in procedures, we were able to identify inadequate equipment, we were able to identify problems in the home life, we would be able to identify substance abuse. And as we went along, what one had was a sense that there were many, many things involved, that there was a range of issues in a matrix that needed to be addressed.

nous devions enquêter sur les circonstances d'accidents mortels parmi les monteurs. On comptait de 10 à 15 décès par an dus à l'électrocution. Grâce à des programmes de recherche fouillés, nous avons pu identifier les causes de ces décès : mauvais temps, procédures fautives, équipement inadéquat, problèmes personnels, toxicomanie. À mesure que nous poussions nos recherches, nous avions le sentiment de l'existence de nombreux, très nombreux facteurs, qu'il existait une gamme de questions se présentant dans une matrice et qu'il fallait les résoudre.

Not all of them were the bailiwick of the ergonomist, but at least the person who was sensitive to human issues was starting to identify them and take them back to human resources, take them back to engineering. After two years of this kind of process, of counting cadavers, we were able to mount a program which, over a period of time, put in place regulations for working in inclement weather, put in place new climbing spurs, put in place new training, put in place more management programs for front-line supervisors, put in place better control systems for substance abuse. And today, they haven't had a fatality in eighteen months and you're going to ask me then, through multivariate statistics, which one made the difference, and I'm going to tell you I don't care because one of the roles of the human factors person is to get information out and apply it and try and find solutions. Another role of the human factors person is to publish papers. And we really have two distinct points of view, it's the same as the chemical engineer and the chemist. I'm a human factors engineer, I'm not a chemist.

Elles n'étaient pas toutes du ressort de l'ergonomiste, mais au moins quelqu'un que le côté humain intéressait commençait à les recenser et en discuter avec les services de ressources humaines, les services techniques. Après deux ans de recherche, deux ans à compter les cadavres, nous avons pu mettre au point un programme qui nous a permis, au bout d'un certain temps, d'élaborer des règlements relatifs au travail par mauvais temps, d'étudier de nouveaux étriers à griffes, de mettre en place un programme de formation pour le personnel et ceux qui les encadrent, et enfin des méthodes améliorées pour lutter contre la toxicomanie. Aujourd'hui, on ne compte pas un décès en 18 mois, et si vous venez me demander laquelle des variables multiples a fait la différence, je répondrai que cela m'est égal étant donné que l'une des fonctions de l'ergonomiste est d'accumuler de l'information et de l'utiliser pour résoudre des problèmes. Une autre de ses fonctions est de diffuser l'information. En somme, il existe deux points de vue distincts, comme la distinction entre l'ingénieur chimiste et le chimiste. Je suis un spécialiste en facteurs humains, pas un chimiste.

So as we go through this process we have to recognize fundamentally for all people concerned just the very, very simple issue of intersect probability. If you have a forgiving environment and a person makes a failure, no problem — if you have an unforgiving environment and the person never makes a

Ainsi, à mesure que nous débattons ces questions, il nous faudra envisager la possibilité fondamentale mais simple, très simple, de l'intersection de deux groupes d'occurrences. Si quelqu'un commet une erreur dans un environnement facile, pas de problème. Si, dans un environnement

failure, no problem; but the intersect probability of these two factors, no matter what defence and depth you have in your engineered system, there will be intersect probabilities (quite often low frequency, high consequence events) where a human will fail. It will be in an unforgiving environment and there will be very negative consequences. When we go through all the debates, on whether it was sleep cycle rhythm or whether it was nutrition or whether it was whatever, to some degree, that's missing the point that a sensitivity to what people can do and cannot do takes us many, many steps down the road, both from an engineering and a managerial point of view. And I think that's the essence of the communications that we're trying to establish between two disciplines. Thanks for that opportunity.

(Ron Kruk)

I appreciate those comments. And from a safety point of view I couldn't agree more. And I have really nothing to add to that.

(Unidentified Speaker)

As a psychologist, people tell me from time to time that psychology is mostly common sense. Since ergonomics is, at least in part, applied psychology, I would be interested in the panel's comments or somebody's comments on whether ergonomics is, at least to a fair extent, common sense and, if not, whether designers and engineers can get the information from handbooks and textbooks?

(France Legault)

One comment I would like to make is concerning the issue of whether there is doubt on the science, if you will, or whether it's

rigoureux, personne ne commet d'erreur, là aussi, il n'y a pas de problème. Mais il y a le risque d'intersection de ces deux groupes de variables, car quels que soient les dispositifs de défense construits pour protéger votre système et qu'elle que soit la profondeur de cette défense, il y aura toujours cette probabilité d'intersection des occurrences (faible probabilité, conséquences graves) qui fera que quelqu'un commettra une erreur. Elle se produira fatalement dans un environnement rigoureux et aura des conséquences graves. Que le débat porte sur le cycle du sommeil, sur l'alimentation ou sur autre chose, on passe à côté de cette vérité que si on se préoccupe de ce que l'être humain peut ou ne peut pas faire, on fera de grands, très grands pas vers la solution du problème qu'il soit technique ou administratif. Et c'est là, je crois, que réside l'essentiel de l'entente que nous voulons faire régner entre les deux disciplines. Merci de m'avoir écouté.

(Ron Kruk)

Merci beaucoup. Du point de vue sécurité, je suis tout à fait d'accord. Je n'ai rien à ajouter.

(Un intervenant qui ne s'est pas identifié)

Je suis psychologue et j'entends souvent les gens me dire que la psychologie est surtout une question de bon sens. Étant donné que l'ergonomie, du moins en partie, c'est de la psychologie appliquée, j'aimerais bien savoir de la part de ce comité ou de quelqu'un d'autre si l'ergonomie n'est pas dans une large mesure une question de bon sens et, dans la négative, s'il ne serait pas possible aux ingénieurs et concepteurs de trouver l'information qu'ils recherchent dans les manuels et traités.

(France Legault)

Le commentaire que je voudrais faire est de savoir si un doute plane sur cette science ou, en d'autres termes, si elle n'en est pas

still not quite yet there. Certainly any accident analysis that I've ever seen points very dramatically to the issue of the human element in any accident that occurs. It seems to me that itself almost argues for rather than casting doubt on the ergonomist, or the ergonomics and human factors issues, or that maybe more rigour and more aggressiveness should be pursued in the methods and methodological development. We no doubt experience in the hard engineering side rigorous quality control in vehicle systems and so on, and yet failures occur and major recalls are made by vehicle manufacturers, so that the engineering system isn't perfect even though it is supposedly coming out of a so-called precise science. The fact that the human element is very predominant or certainly influential in the cause of the accident or the outcome of the accident seems to argue that this science of ergonomics must continue to become more precise and it must continue to be strongly embedded in the analysis of a number of systems and safety is certainly one of them. So even if it's imprecise (and we're not sure and, as the last speaker here mentioned, "I don't care" whether it was this particular root cause) ergonomics must continue to shed light on that part of the whole human, machine and environmental interface.

(Unidentified speaker)

I would only like to make a brief retort to what I've heard and that is that policy costs money. To know the cause of things is to target limited financial resources wisely. In that respect, I think, the more we understand, within reason, from research about the cause of things, the better our policy responses, and the more effective they'll be in saving life and limb.

(Brian Tansley)

It's important, in the context of this discussion about the application of the quote unquote scientific method to the solution of some of these problems, to recognize that the scientific method as it is implemented

tout à fait une. Il est sûr que lorsqu'il y a un accident, on trouve de très nombreux facteurs incriminant l'élément humain. C'est là un argument qui, à mon avis, milite davantage pour l'ergonomie que contre elle et contre l'idée que peut-être il faudrait encore plus de rigueur dans l'étude de méthodes et dans la méthodologie. En tant qu'ingénieurs, nous exerçons un contrôle qualitatif rigoureux sur les systèmes de transport et pourtant, malgré cela, des défaillances se produisent et les constructeurs procèdent à des rappels. On peut donc affirmer que l'ingénierie n'est pas infaillible, même si elle se fonde sur une science que l'on dit exacte. Le fait que l'élément humain joue un rôle décisif ou simplement contributif dans tout accident ou les conséquences d'un accident, cela semble plaider pour que cette science devienne de plus en plus rationnelle, mais aussi qu'elle continue à privilégier l'analyse de toutes sortes de notions, y compris la sécurité. De sorte que, malgré son imprécision (et là je dirai que nous n'en savons rien et, même comme l'a dit le dernier intervenant, que cela m'est égal), il faudra toujours faire appel à l'ergonomie pour éclairer cette partie du problème que sont les interactions entre l'homme, la machine et l'environnement.

(Question de la part d'un intervenant)

Ma réplique à ce que je viens d'entendre sera brève. Qui dit politique dit coût. Aller au fond des choses a pour but de pouvoir affecter à bon escient des ressources financières limitées. À ce titre, j'estime que plus on creuse dans des limites raisonnables, meilleures seront nos politiques et plus grande sera leur efficacité à sauver des vies humaines.

(Brian Tansley)

Dans le cadre de ce débat sur l'application de la méthode dite "scientifique", à la solution de quelques-uns des problèmes qui nous confrontent, il faut reconnaître que la méthode scientifique telle que nous

and the philosophy of it don't work in many of the examples that we're often faced with. In particular, in examples where the probability of the events is extremely low.

The use of multivariate statistics to analyses of level-crossing accidents or airline accidents or railway accidents is almost absurd because one would have to almost wait an infinitely long time in order to get enough data, enough power out of the results to say anything reasonable. I'll give you an example of what I'm talking about. I'm the CIE representative for Canada (this is the International Illumination Commission), and this summer we had a conference in Venice regarding photo-biological effects of ultraviolet illumination. People get skin cancer inside buildings illuminated by fluorescent lights or high-intensity discharge lights. Now the question is, does the high-intensity discharge light cause skin cancer, and if it does, what do we do about it? So a large worldwide study was done four years ago which we've just completed this year by the CIE. The results were published. The incidents of skin cancer per 6 million individuals was estimated at 150 to 200. Now some people think that that might be too much and so we estimated the probability of falling off a chair, changing the lamps and it was about 2000.We estimated the probability of dying by leaving the lamps off, and the probability there was about ten times the result of dying from skin cancer. If it is caused by the light and there is no direct evidence that it is, the point is this, you put a system in place, you do the best you can with the system, you then try to go back and evaluate any adverse effects of it. The point is now that it's in place you have now locked yourself in, to a certain degree, to using certain methods to evaluate the system and to using the system in a certain way. And I don't think there's anybody in this country that would argue that our safety record with respect to rail traffic, as a passenger on board the train, isn't pretty good. At present, my estimation is that your chance of getting killed on a train in this country is about the same as a bucket of water boiling at room temperature. It's closer to that than it is to two numbers that

l'utilisons et la philosophie qui la sous-tend échouent dans plusieurs des cas que nous avons eus à envisager. En particulier, les occurrences dont la probabilité est très faible.

L'emploi des méthodes d'analyse statistique multidimensionnelle, dans l'étude des accidents à un passage à niveau ou des accidents aériens ou ferroviaires, est presque absurde étant donné qu'il faudra attendre une infinité de temps avant de pouvoir accumuler suffisamment de données et d'en tirer des résultats convaincants. Je vous donne un exemple : je suis le représentant canadien de la Commission internationale de l'éclairage, CIE; cet été, nous avons eu à Venise un congrès sur les effets photobiologiques de l'éclairage à l'ultraviolet. L'incidence des cancers de la peau parmi les personnes qui travaillent à l'intérieur d'immeubles éclairés par des lampes à fluorescence ou des lampes à décharge à haute intensité semble anormale. Le cancer de la peau serait-il causé par les lampes à décharge haute intensité? Et dans ce cas, que faut-il faire? Il y a quatre ans, une étude mondiale a donc été faite par la CIE et elle s'est terminée cette année. Les résultats publiés montrent que la fréquence du cancer de la peau a été estimée entre 150 et 200 sur 6 millions d'invidus. Certains pourraient trouver ce chiffre trop élevé. Nous avons donc calculé la probabilité qu'il y a de tomber en bas de la chaise sur laquelle on a grimpé pour remplacer une lampe; elle est de quelque 2 000. Nous avons ensuite estimé le nombre de décès si les lampes n'étaient pas allumées; elle a été établie à environ 10 fois l'incidence de mortalité par cancer de la peau. Si le cancer est causé par l'éclairage, et il n'y a pas eu de preuve directe à cela, alors j'en viens à ceci : vous mettez un système en place après l'avoir bien étudié; puis vous y revenez et évaluez ses effets secondaires. Mais, étant donné qu'il est déjà en place, vous vous trouvez coincé dans une certaine mesure, astreint à utiliser certaines méthodes pour l'évaluer et à utiliser celles-ci d'une certaine façon. Je pense qu'il n'y a personne qui puisse nous dire que la sécurité dans notre réseau ferroviaire, que la sécurité des voyageurs à

make any sense at all for the low probability events that we're talking about are very, very, very difficult to evaluate scientifically. Now the subjective probability is a different story and I think that's what we're responding to here with respect to a lot of these comments. Nobody likes to think of a loved one getting killed on a railroad and nobody likes to think of dying on an aircraft or some of the other examples, getting locked in an elevator in a burning building or all of the other horror stories we can think of. But how to solve these problems in the context of the scientific method, that's not at all obvious and as someone who is trained in the scientific method, I would have to argue that ergonomics and human factors, at present, is much more of an art than it is a science. And I would admonish people who claim to be able to provide scientific analysis to these problems to be very careful when they do so.

bord de nos trains n'est pas bonne. Pour l'heure, j'estimerai le risque de mourir dans un accident de train ici comme à peu près égal à celui d'être piqué par une mouche tsé-tsé au mont Sainte-Anne par –30 °F. En tout cas, il est plus proche de cela que de tout autre chiffre raisonnable, vu qu'il est très difficile d'évaluer scientifiquement une occurrence dont la probabilité est faible. Quant à l'aspect intuitif de la probabilité, c'est une autre chose et je pense que c'est à cet aspect que l'on réagit en écoutant quelques-unes des interventions. Personne n'aime l'idée qu'un être cher décède dans un accident ferroviaire, qu'on puisse mourir un jour dans un accident d'avion ou être coincé dans un ascenseur lorsqu'un incendie fait rage dans l'immeuble, ni imaginer tout autre histoire horrible de ce genre. Mais, comment résoudre ces problèmes par la méthode scientifique, voilà qui n'est guère évident. Étant de formation scientifique, je prétends que l'ergonomie, pour l'instant, relève beaucoup plus d'un art que de la science. Et je conseille à ceux qui prétendent pouvoir appliquer l'analyse scientifique à ces questions d'être très prudents dans leur approche.

(Ron Kruk)

Okay, having been admonished to be very careful, let me go back to the original comment, well isn't human factors just common sense? And can't we get most of it out of a cookbook. I'd have to say that it depends. There are many cases where you can take up a human factors or industrial design book and, if you have to have an operator that sits down in front of a console somewhere, it's pretty easy to pick out yes you should have a chair there if you want him to sit, and it should be this high and should be this wide and it should have armrests that move up and all sorts of things. Unfortunately most of those cookbooks, when involved in more dynamic aspects, like how many colours should you use in a display on a CRT or how should you format the information on this particular page, tend to give you a whole list of options. You could do this, or you could do that, or you could do that. So you can take a cookbook up until the point where the

(Ron Kruk)

Bon, après ce conseil de prudence, je reviens à la remarque qui a tout déclenché: l'ergonomie après tout n'est-elle pas que l'expression du bon sens? Ne la trouve-t-on pas dans n'importe quel manuel ou traité d'ergonomie? À cela je réponds : ça dépend, dans un certain nombre de cas, oui. En effet, s'il faut qu'un opérateur prenne place devant un pupitre quelconque, oui il est facile de dire qu'il lui faudra une chaise, de telle hauteur, de telles dimensions, avec des appuis-bras relevables, etc. Sauf que, lorsqu'on passe à un autre ordre de préoccupations — par exemple, combien de couleurs faut-il qu'un écran cathodique affiche, ou bien comment formater telle ou telle information? — la plupart des traités proposent généralement plusieurs solutions parmi lesquelles il faut choisir. Il y a cette solution-ci, puis celle-là et une autre encore. Ce livre peut vous aider jusqu'à un point au-delà duquel vous n'en sortez plus et vous

cookbook starts giving you all sorts of alternatives and then you have to find somebody who's within the constraints of your own specific design. And the reason they put all those options in the book is because people have designs for different kinds of applications and maybe Option A doesn't work very well for you. So at the very least, at that level, someone has to explain to the design engineer or the staff, what the sources for those options are, what for any particular application is the option made. You get beyond that point, or up to third level, getting even sloppier, there are points where there's no cookbook answer and you're going to have to spend the money to get the research done to find out the answer. It may not cover the entire level of what you want to do, especially with some of the more advanced technology systems that are on line these days, but that's the level. Yes, there are some times when this is straight common sense, there are some times when someone has to explain the options that are in the book, there are some times when the common sense is strictly a post-op phenomenon — it looks pretty simple after you've done it.

(Ben Barkow)

I'm less cautious than most people and hate to leave a meeting without putting my foot in my mouth. We've been doing human factors for about twenty years. I used to be at Bell labs and we used to study memory for seven digit numbers. That was about twenty-three, twenty-four years ago, a long time ago. I would like to say that we're always hired by the people who need us the least, the people who sort of are opaque to issues of human factors, do not know they're opaque about them, do not know they have a problem. I would like to draw an analogy, something very personal, and I hope no one blushes, but I went to get some arches for my shoes the other day and I went into the clinic and the therapist said "Walk up and down". I took a couple of steps and she said "Your left leg is about a couple of millimetres short and you have a scoliosis about

devez alors trouver quelqu'un qui a déjà étudié le même genre de problème que celui qui nous concerne. Or, la raison pour laquelle ces livres contiennent tant de solutions différentes, c'est parce qu'à chaque application peuvent correspondre diverses solutions. Si, par exemple, la solution A ne vous convient pas tout à fait, il y a la solution B, et ainsi de suite. Donc, à ce niveau du moins, il faut quelqu'un pour montrer à l'ingénieur ou au concepteur les sources d'information à consulter, là ou les solutions correspondant à telle ou telle application. Au-delà, ou à un niveau encore plus élevé, les choses se gâtent. Là, il n'y a plus de solutions prêtes et pour en trouver, il vous faudra faire appel à un expert et cela coûte de l'argent. Il ne répondra peut-être pas à toutes vos questions, surtout de nos jours avec toutes ces technologies de pointe, mais cela sera au moins quelque chose. Donc, oui, il y aura des cas où le simple bon sens peut suffire et d'autres où il faudra quelqu'un pour expliquer les solutions proposées dans les traités. Mais il est des cas aussi où le bon sens ne se constate qu'après coup, c'est-à-dire après que le choix ait été arrêté et mis à exécution.

(Ben Barkow)

En ce qui me concerne, je suis moins prudent que la plupart et je n'aime pas rater l'occasion de dire des sottises. Cela fait au moins vingt ans que nous faisons de l'ergonomie. J'ai travaillé dans les laboratoires de Bell et j'ai participé à la recherche sur la mémorisation des nombres à sept chiffres. Il y a de cela vingt-trois, vingt-quatre ans, c'est bien loin. Le fait est que les employeurs qui nous engagent sont ceux dont on s'y attendrait le moins, des gens plutôt insensibles aux facteurs humains, qui ne le savent pas et qui ne s'en inquiètent même pas. J'aimerais établir une analogie, c'est un peu personnel et j'espère ne faire rougir personne. Voici : un jour je suis allé me procurer des cambrures pour mettre dans mes souliers. J'entre dans la clinique et la spécialiste m'a demandé de faire quelques pas. Après m'être exécuté, elle

seven vertebrae down", and on and on about all the things perfectly obvious and transparent to her. I've had this fantasy, please excuse me if I'm going on in a personal way, I've had this fantasy for many years that the right way to convince people, client-like people, people I want to give human factors to, is to give them a little tour. And that normally is how we get our environmental psychology business. We go into a building that's underway, let's say the Domed Stadium, and they say "Here's the Domed Stadium. Isn't it marvelous?" We say "look at that, that's a great place for a little mugging, isn't it?". And they say "By George, you're right." Well, my point, and excuse me if I'm wandering, my point (and I know all the human factors people here know what I'm saying) is that human factors people see lots of things that people who don't devote their entire lives to the applied psychology of everyday life, do not see. Not many people here, I would suppose, know that you can't grasp the handrail out there. Or, if they have a close look at the silly and unnecessary level changes that you go through, that none of the ramps or the inclinators that help people who use wheelchairs would be necessary. There's a whole world of stupidly done human factors that are invisible to most people, but to us and with our common sense and vision, it's really out there — all kinds of problems with design of the world. If you're not part of that world, if you don't sort of experience it everyday, you don't know it's there, you don't know it's a problem and you can believe that the design of the car that you drive is the way that it was intended to be.

(Ron Kruk)

Then maybe it isn't a problem.

me dit: "Vous boitez légèrement de la jambe gauche et vous avez une scoliose au niveau de telle vertèbre, etc.." Elle m'a dit des tas de choses tout à fait évidentes pour elle. J'ai toujours eu un dada, celui d'emmener les personnes que je veux persuader de l'utilité de l'ergonomie à faire un petit tour sur le chantier. Ce que j'appelle de la psychologie appliquée. Je les emmène dans un bâtiment en construction, disons un stade couvert. Elles s'exclament: "Mais c'est magnifique, ce qu'il est beau!". Alors je leur dis: "Voyez ici, quel endroit idéal pour une agression, n'est-ce pas?" Elles répondent: "Mais oui, vous avez raison." Mon argument, et je m'excuse si je divague un peu, mon argument, et je suis sûr que tous les ergonomistes présents dans la salle savent où je veux en venir, est que les ergonomistes remarquent des détails qui passent inaperçus à ceux qui ne font pas de la psychologie appliquée à longueur de journée. Peu de gens, en effet, ont remarqué que cette rampe donne peu de prise, ou bien toutes ces dénivellations inutiles sans lesquelles aucun des plans inclinés et aucun des monte-escaliers destinés à aider les personnes en fauteuil roulant n'auraient été nécessaires. Il y a tout un monde de détails aberrants, invisibles à la plupart, mais qui nous sautent aux yeux à nous qui avons notre bon sens et notre vision propre des choses. Et il est là ce monde de problèmes. Si vous ne faites pas partie de ce monde, si vous ne l'éprouvez pas en quelque sorte jour après jour, vous ne vous en rendrez pas compte, vous ignorerez que c'est un problème et vous finirez par croire que l'auto que vous avez achetée n'a pas été voulue autrement que comme elle est.

(Ron Kruk)

Mais alors, peut-être qu'il n'y a pas de problème.

(Ben Barkow)

You don't see the problem. Take a building, for example; the architect designed it, the building inspector and ten thousand other people don't know, and don't care until somebody starts complaining and tries to get changes made. So when do you know you need it? Do you wait until you have an accident? Well that's a difficult question and what we do with the human factors is we try to convince our clients that they should bring us in and consult us just a little bit, let us have a look, and then we sort of identify the main problem. We say that we don't want round doorknobs. I was in a hotel recently; they have four doors, three have round ungraspable doorknobs and the fourth is the medical door, and that happens to have a doorknob that anyone can use. Our place is sort of wherever people come in contact with our world. Buildings, objects, trained people, untrained people. I don't know where we're not needed, but of course I'm biased about that.

(Ron Kruk)

I'm not going to say it sounds like selling life insurance but it does a bit.

(Ruth Heron)

I would like to speak to a couple of issues that have been raised here. First, some of the things we come up with may sound like nothing more than common sense, but, as Ron Kruk said, that is always the case after the fact. It should be understood, in any case, that we do have a large body of scientific knowledge behind us. Secondly, each and every one of us has been highly trained, not only in the scientific method and experimental design, but also in highly sophisticated data analytical techniques — multivariate analysis, multidimensional scaling, log linear methods, fuzzy set techniques, information theory, you name it. So we're very much the scientists, and quantitative

(Ben Barkow)

Il n'y a pas de problème tant que vous ne le voyez pas. Prenez le cas d'un immeuble. L'architecte qui l'a conçu, l'inspecteur qui l'a revu et des milliers d'autres ne savent pas, ne se préoccupent pas de savoir s'il y a un problème jusqu'à ce que quelqu'un s'en plaigne et demande qu'on y remédie. Alors comment savoir. Faut-il attendre l'accident? Question difficile! Ce que nous faisons est de persuader le client qu'il est dans son intérêt de nous laisser jeter un coup d'oeil, pour déceler le bobo, comme les boutons de porte. Dans un hôtel où je me suis trouvé récemment, il y avait quatre portes, trois avec des boutons n'offrant aucune prise et une quatrième à poignée de type médical, la seule d'ailleurs que tout le monde pouvait actionner. Notre place c'est le monde entier : immeubles, objets, opérateurs entraînés ou non. Y a-t-il un endroit où l'on n'ait pas besoin de nous? J'en doute, mais bien sûr, je risque d'être partial.

(Ron Kruk)

Je ne dirai pas que c'est un peu comme vendre de l'assurance. Mais c'est un peu comme ça.

(Ruth Heron)

Je voudrais aborder une ou deux questions soulevées ici. D'abord, l'ergonomie repose sur un vaste corps de connaissances. Certaines des solutions que nous pouvons préconiser peuvent paraître marquées au coin du simple bon sens mais, comme l'a si bien dit Ron Kruk, c'est toujours après coup qu'on s'en rend compte. Ce qu'il faut faire admettre, c'est qu'elles sont toujours fondées sur des connaissances scientifiques. Deuxièmement, nous avons tous été formés non seulement à la méthodologie scientifique et à l'expérimentation, mais aussi dans les méthodes analytiques très avancées: analyse multicritère, multidimensionnelle, log linéaire, les ensembles flous, la théorie de l'infor-

ones at that. In the applied situation, we do use the scientific method, as it is often necessary to take certain questions back to the laboratory for controlled testing. But apart from that, we don't go into the field just speculating in some sort of common-sense fashion — we go in with well stocked bags of methodological techniques and quantitative tools — and, with these, we apply well defined strategies that allow us to detect and define the human factors problems of complex systems in a systematic comprehensive way.

(Pat Hallett)

Not terribly unlike a medical practitioner who has a lot of diagnostic experience and so on, perhaps research experience, and he sees a patient and sees something and says "The problem might be" and it sounds very simplistic but it's in fact backed up by an awful lot of data and input.

(Leslie Buck)

The talk has gone, just now, on the matter of safety. I think we need to keep the thing in balance because while safety is a very important issue, so also is performance, productivity, how we get on when we don't make mistakes, how we can do whatever we do more efficiently. I feel sorry for CN, if I can make this point, because the accident happened to them, and that was too bad. I mean it happened to the people on the train as well, which was even worse but it could have happened on CP equally as well. And I'm sure as ergonomists we could go and put the finger on CP, we could put the finger on Air Canada, we could put the finger on any transportation company and say there are things you do which are liable to lead to trouble and perhaps you're going to have

mation, etc. Nous sommes bel et bien des scientifiques, versés dans les techniques d'analyse quantitative. En ce qui concerne les applications, nous nous servons de méthodes scientifiques, étant donné qu'il arrive souvent d'avoir recours à des essais de laboratoire dans des conditions contrôlées. De plus, nous ne nous rendons pas sur le terrain armés de vagues spéculations, nous y amenons nos vastes réserves de techniques et d'outils de prévision, grâce auxquels nous mettons en oeuvre des stratégies bien définies permettant de produire de l'information utile sur divers problèmes à caractère ergonomique. Ces stratégies nous permettent de mettre en évidence et de définir les facteurs humains en jeu dans des systèmes complexes, avec autant de méthode que de minutie.

(Pat Hallett)

Ce n'est pas différent du généraliste dont la vaste expérience pratique et peut-être quelques stages de recherche lui permettent d'être un bon diagnostiqueur. Quand il voit un patient, il lui dit: "C'est probablement ça." La méthode paraît simple mais elle est fondée sur des connaissances et de l'expérience.

(Leslie Buck)

Le débat a dévié sur la question de la sécurité. Je crois qu'il faut mettre les choses en évidence étant donné, bien sûr, que la sécurité c'est très important, mais il y a aussi le rendement, la productivité, que faire en cas d'erreur, comment relever l'efficacité. Je plains le CN qui a eu à souffrir de cet accident, c'est dommage! Je sais que ceux qui étaient à bord ont également eu à en souffrir, ce qui est pire, mais l'accident aurait pu aussi bien arriver au CP. Je suis sûr qu'à titre d'ergonomistes, nous pourrions pointer du doigt le CP ou n'importe quel autre transporteur et leur dire qu'ils prennent des risques pouvant mener à un accident. C'est malheureux cet accident, mais soyons honnêtes, nous avons saisi cette occasion pour mieux nous faire

an accident. The accident is unfortunate and let's be honest about it, as ergonomists, as a profession, we have grabbed hold of this thing because it has enabled us to make our point. Now it is a bit unfair in a way, because, as it were, we're leaning on the unfortunate company of CN. But until that sort of thing happens, who listens to us? So be forgiving if in fact we do, as it were, exploit the situation. But these situations do exist, and if it's unfortunate that it happens to have happened in Hinton on that particular occasion at that particular time, it could equally well have happened in other places and the thing is to look at them all. Not just at one — all our working situations need the contributions that ergonomists can make. Why? It comes back to the first point I think I made this morning — there is always a human operator. Now if you're going to look at human operators, you need people who trained in the appropriate disciplines. If I wanted to build a bridge, I could do it up to a point, after all you throw a plank of wood across a river, that's a bridge. And you walk across it. But if you're really serious, you go to a civil engineer. I dare say that if I read up enough books about diesel engineering I might even be able to design a diesel locomotive, and if I could persuade someone to build it, it might even work, maybe. But you know if you want to build a diesel locomotive you go to a diesel engineer. You go to the people who know something about it. There is always a human operator in the system, you can't avoid it. There is a body of knowledge, it may need expanding. It's theory at the moment. It isn't as good as we'd like to see it. We'll only improve the theory by doing more research. In the meanwhile, in the real world, whatever knowledge we have does need to be applied. And you're not going to get it from cookbooks, you're going to get it from people who do have the information, who have the sensitivity Ben Barkow was talking about, to see things in these kind of terms. I think we should all cooperate together over this. I don't claim to be a civil engineer or diesel engineer. Why should a diesel engineer claim to be an ergonomist?

connaître. C'est un peu injuste parce que nous profitons du malheur qui a frappé le CN. Par contre, lorsqu'il n'y a pas d'accident, nous prêchons dans le désert, pour ainsi dire. D'accord, nous exploitons en quelque sorte la situation, mais ce sont des situations qui arrivent et c'est malheureux que l'accident se soit produit à Hinton, ce jour-là, à cette heure précise. Il aurait pu se produire n'importe où ailleurs, mais il faut les envisager tous. Non pas un seul accident, mais toutes ces situations où l'ergonomie est susceptible d'apporter une contribution positive. Pourquoi, parce que, pour revenir à ce que j'ai dit dans la matinée, on a toujours affaire à un opérateur. Lorsqu'il s'agit d'étudier les conditions de travail d'un opérateur, il faut s'adresser à ceux qui ont étudié les disciplines appropriées. Si je veux franchir un ruisseau, je peux toujours me débrouiller par moi-même, je n'ai qu'à placer une planche de bois et le tour est joué. Mais à partir d'une certaine largeur, je devrais m'y prendre d'une autre façon et m'adresser à un ingénieur civil. Il est probable que si je lis suffisamment de livres sur les moteurs diesel, je serais peut-être capable de concevoir une locomotive diesel et si j'arrive à amener quelqu'un à la fabriquer, il se pourrait même qu'elle se mette à fonctionner. Peut-être, mais vous savez que pour construire vraiment une locomotive diesel, il faut s'adresser à un ingénieur diéséliste. On s'adresse toujours à un spécialiste. Or, dans tout système il y a toujours un opérateur humain qui, lui, est du ressort de l'ergonomiste. Il existe un bloc de connaissances qu'il faut enrichir. C'est la théorie qui, pour l'instant, a besoin d'être perfectionnée. Et elle ne pourra l'être que par la recherche. Entre-temps, le monde a besoin de nos connaissances. Et vous ne les trouverez pas dans un livre de recettes, mais chez ceux qui savent et qui ont cette sensibilité dont Ben Barkow a parlé, celle de voir les choses avec l'oeil du spécialiste. Je pense que nous devons tous travailler ensemble. Je ne me dis pas ingénieur civil ou ingénieur diéséliste, alors pourquoi un diéséliste voudrait se prétendre ergonomiste?

(Dan Buckingham)

I think we kind of retrogressed a little bit here to an argument between engineering and what the ergonomic world has to offer. I work for Ontario Hydro, and the ergonomics people and the human factors people in our company are just a new wave sort of coming through. Being a user of a number of the products being developed by engineers where we've had to make do because somebody didn't look at what the human was going to do and how the human was going to perform using that piece of equipment, has led to my involvement with the group. I have found that, in the last three to four years, the products being produced by engineers that have listened to ergonomics people and who have taken their advice in terms of putting the human into the mechanical world, have had a great deal more success by doing so. And I'm glad to see that some groups here are working as teams, having an ergonomist or a human factors person on an engineering group, there's some advice being passed back and forth, and everybody learns a little bit. It does bother me though when I hear people setting up opposing groups, one against the other. I don't think that's the purpose of a meeting like this. The purpose is to look at what each group has to offer and make the best of both worlds.

(Bob Radford)

I just have one comment. On the subject of the ability to be a diesel engineer or think in another term, I have known many people who are not professional engineers who could yet design things in an excellent way. Henry Royce was not a theoretician but he knew if something was right. Closer to home, my wife does not have a degree in domestic science but as anyone who knows her will testify, she's an excellent cook. So that things can be done by nature, I claim. One of the things that I feel disappointed to read is in one of the things I picked up from your society claiming things that report published by the CTC '84 pointed out that condi-

(Dan Buckingham)

Je crois que nous sommes en train de revenir malheureusement à une discussion qui oppose l'ingénieur à l'ergonomiste. Je travaille pour Hydro Ontario, et les ergonomistes qui y sont employés commencent seulement à se faire écouter. Ayant eu à me servir de divers objets étudiés par nos ingénieurs, je me suis aperçu que plusieurs avaient été conçus sans réellement penser à la façon dont un être humain devra s'y prendre pour s'en servir. C'est ce qui m'a poussé à travailler avec les ergonomistes. J'ai constaté que depuis les trois ou quatre dernières années, les objets produits par nos ingénieurs qui avaient écouté les ergonomistes et mis en pratique leurs avis sur la façon d'intégrer l'être humain au sein d'un monde mécanique, que ces objets étaient mieux pensés. Et je suis content de voir que certaines équipes comportent un ergonomiste, qu'il y a échange d'information et que tout le monde en profite. Il ne me plaît pas d'entendre des gens vouloir opposer un groupe contre l'autre. J'estime que ce n'est pas là l'objectif de ce séminaire, mais celui d'écouter ce que l'autre a à dire et d'en tirer profit.

(Bob Radford)

Juste un mot sur la capacité d'être ingénieur diéséliste ou autre. J'ai connu plusieurs personnes qui, sans être ingénieurs diplômés, pouvait construire de belles choses. Henry Royce n'était pas un théoricien, mais il savait si cela pouvait fonctionner ou non. Ma femme, bien que n'étant pas diplômée en sciences ménagères, cuisine très bien, d'après le témoignage de ceux qui la connaissent. Donc, il est possible de faire des choses sans avoir appris. Par ailleurs, ce qui me déçoit quand je lis dans une publication de votre association que, d'après le rapport publié par la CCT en 1984, les conditions dans les postes de conduite des locomotives

tions in locomotive cabs are, in some respects, bad enough to contravene local health and safety regulations. And holding that as if it's typical of locomotive cabs when in fact careful reading of it will see that the criticisms really applied to some of the much older cabs, not to the majority of mainline locomotives that they're running now.

So I think it's very important that, if as a group, human factors engineers are going to assist in any industry, their investigation be done very carefully. Not, as I tend to see it, in a somewhat superficial way.

(Don Donderi)

I'd like to speak for somebody who is absent, and that is Alison Smiley, just to assure the gentleman who spoke from CN that the investigation was not done in a superficial way in this particular case. She can speak for herself, I didn't realize she was still here. We shouldn't be fighting, there's no question about that, but we also should be representing the facts about what was done correctly.

(Barry Myers)

Just to pick up on an earlier point about when to apply ergonomics I think I have to agree with what I felt that David was saying, that really it's a question of what does it cost, and how effective is it and what benefits can you get from it? And I'd like to give a little anecdote of my own. For many years I was an aerodynamicist, and aerodynamics I think at that time was much more of an art than a science. The automotive industry, though, didn't need aerodynamics engineers; they designed their vehicles without the use of these professionals and they obviously knew how to design them, and it was only when the economics really required that vehicles have much lower drag that you really saw the application, truly the application of the science of aerodynamics to the automotive vehicle. I think that may be a good analogy here.

sont, à certains égards, mauvaises au point d'enfreindre les règlements de santé et de sécurité, laissant entendre que cet état de choses se retrouve dans tous les postes de conduite. Mais on s'aperçoit lorsqu'on lit le rapport avec soin, que cette critique s'applique aux vieilles locomotives et non à celles qui sont en service actuellement.

J'estime important donc que les ergonomistes, s'ils veulent collaborer avec le reste de l'industrie, ne s'arrêtent pas à la surface des choses, mais les approfondissent.

(Don Donderi)

Je voudrais parler au nom d'une absente, soit Alison Smiley et assurer le dernier intervenant qui a parlé au nom du CN que l'enquête n'a pas été superficielle, en l'occurrence. Elle peut se défendre elle-même, mais je ne savais pas qu'elle était encore ici. Nous ne devons pas nous battre entre nous, mais il faut mettre les choses au clair.

(Barry Myers)

Pour revenir à la question de savoir quand l'ergonomie devient utile, je pense être d'accord avec ce que David a dit, qu'il s'agit avant tout de savoir combien cela va coûter, quelle est son efficacité et qu'est-ce qu'on peut en tirer. Je voudrais vous faire part d'une anecdote : pendant plusieurs années, j'ai travaillé comme aérodynamicien et, à cette époque, l'aérodynamique était plus un art qu'une science. L'industrie de l'automobile n'avait pas besoin d'ingénieurs aérodynamiciens. On dessinait les voitures sans avoir recours à eux et ça marchait. Ce n'est que lorsque le besoin s'est fait sentir sur le plan économique de réduire la traînée qu'on s'est aperçu que l'aérodynamique pourrait être vraiment utile. Je pense que l'analogie est pertinente.

(Ron Kruk)

I'm going to take charge and make the last comment. By definition, if you involve the human factors specialist in the system well after it has been designed, built, implemented, brought into operation, comments about it — given that you've had a problem with it, and that's your reason for bringing an ergonomist into the system — those comments are going to be criticisms. Because you've got something that exists and you've got a problem with it, and you want to find out what the sources of those problems are. So by and large as long as you have human factors inputs into systems and devices well after the design is frozen, the kinds of statements you're going to get from human factors specialists about those systems are going to be criticisms. I would like to make the point, once again, that if a human factors specialist is a part of the design team for a system — given that you need a human factors specialist in the first place and I'm not going to argue when you need it and when you don't — then if you bring the human factors specialist in early, if he or she is a major part of the design process for that system, then it's likely that most of the human factors comments with respect to that system are going to be suggestions, for improvements on the design rather than criticisms on how poorly it was done in the first place. And I think since we're running well overtime that we're going to stop with that.

(Ron Kruk)

C'est maintenant à moi de conclure. Il me semble que lorsque vous faites appel aux ergonomistes au sein d'une équipe d'étude après que le système considéré soit passé par les stades de conception, réalisation, mise en oeuvre et mise en service, pour résoudre un certain problème, il est inévitable que les propos de l'ergonomiste apparaissent comme des critiques. Voilà un système qui a un défaut et vous voulez le corriger. Donc, chaque fois que vous ferez appel à un ergonomiste dans un but correctif, il est inévitable que ses opinions vous paraissent comme des critiques. Je reviens sur le point que si l'ergonomiste fait partie de l'équipe d'étude d'un système donné, à supposer que vous ayez besoin d'un tel ergonomiste — et il ne m'appartient pas de vous dire si vous avez besoin de ce spécialiste ou si vous pouvez vous en passer — il faut alors qu'il y participe dès le début. Et dans ce cas, il est possible que les propos qu'il ou qu'elle tiendra au sujet du système à l'étude seront de nature à améliorer celui-ci et ne seront donc pas des critiques sur le produit ni sur ses faiblesses inhérentes. Bon, je dois terminer car nous sommes déjà en retard sur l'horaire.

CLOSING REMARKS

Marc Brenckmann

I think at this point I would like to thank the panel and the audience for having provided us all with a very interesting and stimulating discussion. It's always a bad sign if everybody agrees at the end of one of these sessions and we had some healthy disagreements.

I would like to thank the Human Factors Association of Canada for having contributed wine to the lunch today. I would like to also thank the organizers of this event which comprised Wayne Rowan, Ruth Heron, Marcel Therrien, Dina Iwanycky, and Leslie Buck as the main people responsible for this seminar. I would also like to advise, particularly those who are out of town, that there is a cash bar available at this time at two places outside the conference rooms, and you can use these facilities both for after-the-seminar discussions and for your dinner. This then concludes this seminar.

ALLOCUTION DE FERMETURE

Marc Brenckmann

Avant de terminer, je voudrais remercier les intervenants ainsi que l'auditoire pour ce débat si intéressant et si instructif. Il n'est jamais bon, à l'issue d'un tel débat, que l'unanimité règne et je me réjouis des désaccords qui se sont manifestés.

Merci aussi à l'Association canadienne d'ergonomie pour avoir fait en sorte que notre déjeuner soit arrosé de bon vin. Merci également aux organisateurs : Wayne Rowan, Ruth Heron, Marcel Therrien, Dina Iwanycky et Leslie Buck. Enfin, pour ceux qui ne sont pas de Montréal, et pour tous les autres, il y a un bar payant ouvert, à droite dès que vous passez les portes vitrées et aussi un restaurant ... qui est dans la même direction mais au bout du hall. Je vous invite à y poursuivre le débat d'aujourd'hui. Mesdames et messieurs, le séminaire est clos.

EPILOGUE

Now that we have enjoyed an unhurried reading of the transcript of the seminar, our impressions of it have had a chance to crystallize, and so perhaps it will be worthwhile to convey some of these to those who participated.

First, we must comment appreciatively on the large representation of transportation managers at the seminar, for this surely was an indication of the timeliness of the event. We hope they went away feeling it was useful, despite certain unavoidable limitations in the scope of the program. Apropos of these, we had recognized early on that, confined as it was to one brief day, the seminar could do little more than open up doors, could provide opportunity for only a preliminary exchange of information and views, which, as a consequence, would raise more issues than could be dealt with in the time available. Some of these issues surfaced during the lively panel/audience discussion, happily so, as certain gaps in understanding could then be identified.

One of these gaps is inherent in Mr. Radford's use of the word "cause" — he had apparently hoped to learn of some cause of the Hinton train accident from Alison Smiley's report. The use of this word is very interesting because it points up an important difference in how ergonomists and engineers think about certain types of problems. The Newtonian scientific model, on which much of engineering is based, supports a mechanical approach to problems and the underlying notion of cause. Thus, in investigating the breakdown of a machine, an engineer looks for some part or thing (say, a broken axle, or something plugging a drain) the repair or removal of which allows the machine to operate smoothly again. However, as Leslie Buck explained, the ergonomist uses mainly the systems approach (attributed to various 20th century scientists) in which causality has no utility because, in a system, every variable is related to every other. Therefore, in an accident investigation, the ergonomist, first, systematically isolates all the facts regarding the human/

POSTFACE

Maintenant, que nous avons pu lire à tête reposée les procès-verbaux des débats et que nos impressions ont eu le temps de décanter, il est temps de les récapituler.

Tout d'abord, nous nous félicitons de la présence en grand nombre de spécialistes des transports, ce qui est gage de l'opportunité du séminaire. Nous espérons qu'ils ont le sentiment d'avoir participé à quelque chose d'utile malgré les lacunes évidentes que l'ordre du jour a pu présenter. À ce propos, nous savions dès le début que ce séminaire d'un jour ne pouvait pas donner beaucoup, à part l'occasion d'échanger des idées et des réflexions et de permettre l'amorce d'un débat fructueux. En effet, grâce au débat de clôture, certains malentendus ont pu être mis à jour.

L'un d'eux a rapport à l'emploi qu'a fait M. Radford du mot "cause" — manifestement, il avait espéré apprendre du rapport présenté par Alison Smiley quelque chose sur la "cause" de l'accident ferroviaire de Hinton. L'emploi de ce mot est très intéressant car il souligne la manière différente qu'ont les ergonomistes et les ingénieurs d'aborder certains types de problèmes. Le modèle scientifique newtonien sur lequel reposent presque tous les principes de l'ingénieur, est basé sur un point de vue mécanique et sur la notion sous-jacente de "cause à effet". Ainsi, chargé d'enquêter sur une défaillance mécanique, l'ingénieur cherchera à isoler une pièce ou un organe (disons, un essieu brisé ou un drain encrassé) qui, une fois réparé ou remplacé, permettra à la machine de fonctionner comme avant. Mais, comme nous l'a expliqué Leslie Buck, l'ergonomiste adoptera une approche systémique (attribuée à différents scientifiques du XX^{e} siècle), selon laquelle le principe de causalité n'a guère de place parce que, dans tout

machine interactions leading up to it. Next, adding relevant scientific knowledge to this pool of facts, he/she identifies the variables that would significantly contribute to the probability of the accident's occurrence. The ergonomist's recommended action for reducing the probability of a future accident is, then, to change the state of one or more of these variables — through regulation, design, policy, or whatever. Dan Buckingham gave a good example of how this approach was effective in reducing Ontario Hydro lineman fatalities, later adding the forceful concept of intersect probability. It cannot be said of these two very different approaches — causal and probabilistic — that one is right and the other is wrong. Rather, each is productive in one context and not in another. In a person/machine system, the two can be made to work complementarily, and this is why we want to say that the role of the ergonomist complements that of the engineer.

système, toutes les variables sont en interdépendance mutuelle. Donc, lors d'une enquête sur les causes d'un accident, l'ergonomiste cherchera tout d'abord à isoler systématiquement tous les faits relatifs aux interactions homme-machine ayant abouti à cet accident. Ensuite, considérant ces faits à la lumière de connaissances scientifiques pertinentes, l'ergonomiste voudra cerner les variables ayant pu contribuer de manière significative à la probabilité de cet accident. Puis, il proposera de modifier l'état d'une de ces variables ou plus, d'une manière ou d'une autre : réglementation, conception, politique ou procédure, pour réduire le risque qu'un accident semblable se reproduise. Par l'exemple qu'il nous a donné, Dan Buckingham a montré comment cette approche a permis à Hydro Ontario de réduire le nombre d'accidents mortels parmi les monteurs, processus qu'il explique grâce à la notion de "probabilité d'intersection des événements". On ne saurait dire de ces deux concepts : causaliste et probabiliste, que l'un est vrai et que l'autre est faux. Il faudrait plutôt dire que tel concept est utile dans un contexte et non dans un autre. À l'égard d'un système homme-machine, il se pourrait que les deux concepts se complètent et c'est pour cette raison que nous disons que l'ingénieur et l'ergonomiste se complètent.

Other comments from the manager group during the final discussion relate to how ergonomists ply their craft. For example, it was questioned, on the one hand, whether their methods are sufficiently rigourous — scientifically and quantitatively — and, on the other, whether the scientific method can be applied at all to ergonomics problems. The uncertainty reflected here about ergonomics is not surprising. Although well established in Europe, the discipline is just beginning to take root on this continent, and time is needed before uncertainty about it will disappear. Perhaps it will fade somewhat if a distinction is made between what ergonomists do in the laboratory and what they do in the field. In the former setting, they conduct research, using the scientific method, either to build up their body of

D'autres commentaires ont été apportés par le groupe des gestionnaires durant le débat de clôture sur la méthodologie pratiquée par les ergonomistes. D'une part, on s'est demandé si les méthodes utilisées ont assez de rigueur du point de vue scientifique et quantitatif et, d'autre part, si la méthode scientifique peut être appliquée à tous les problèmes que l'ergonomie tente de résoudre. Le doute que cela sous-entend concernant l'ergonomie n'a rien de surprenant. Bien qu'ayant droit de cité en Europe, cette discipline n'a pas encore de racines profondes sur notre continent, et seul le temps pourra dissiper la méfiance entretenue à son égard. Mais on y parviendrait plus vite si l'on apprenait à bien distinguer entre ce que l'ergonomie vise à faire en laboratoire et ce qu'elle cherche à

knowledge about how humans function in interaction with machines, or — as Bob Dewar frequently does for his work on traffic signage and vision in vehicles — to resolve some problem prior to development of a product or system. Their laboratories are equipped with all that modern technology can provide for accurate observation and measurement — for example, Ian Noy's has an advanced model driving simulator. In the field, ergonomists do some research, often using multivariate methods to effect statistical control of variables that cannot be manipulated as they are in the laboratory. But mostly ergonomists do applied work in the field, carrying out investigations of errors and accidents, evaluations of existing products or systems, and consultations during product or system development. In these cases, they use a variety of strategies and methodological techniques. The mathematical approach taken by Robert Gilbert for the Montreal Metro vigilance problem, the computer-aided design approach Franz Schneider applied to the design of a people mover, and the systems/task analysis method Ruth Heron used to evaluate Communicaid — these are but a few in the very wide range of examples. Of course, in addition to its formalized approaches in applied work, ergonomics — like any area of expertise, whether it is law, medicine, engineering, or whatever — has its heuristic methods and procedures. And so, in sum, it can be said that ergonomists qualified as such are highly trained both as researchers and practitioners, with part of their expertise lying in knowing precisely which design or technique to use in either case to solve a given problem.

réaliser sur le terrain. Dans un laboratoire, l'ergonomiste fait des recherches à l'aide des méthodes scientifiques dans le but soit d'enrichir ses connaissances scientifiques sur le comportement de l'être humain face à une machine, soit de résoudre un problème précis par rapport au développement d'un produit ou d'un système, comme Bob Dewar est souvent appelé à faire dans le domaine de la signalisation urbaine et de la visibilité des signaux. Les laboratoires d'ergonomie sont équipés d'instruments ultra-modernes permettant de procéder à des observations et mesurages de grande précision, exemple le simulateur de conduite avancé que Ian Noy utilise. Sur le terrain, l'ergonomiste fait aussi de la recherche, utilisant souvent des méthodes d'analyse statistique multidimensionnelle qui permettent de contrôler les variables à tour de rôle. Mais, surtout, il intervient dans l'étude des erreurs, des sources d'erreurs et d'accidents; il évalue des systèmes ou produits existants et il conseille ceux qui en conçoivent de nouveaux. Qu'il fasse de l'évaluation ou de la consultation, la gamme de stratégies et de techniques à sa disposition est vaste. L'approche mathématique suivie par Robert Gilbert pour résoudre le problème de la vigilance au métro de Montréal, la méthode de conception assistée par ordinateur que Franz Schneider a appliquée à l'étude d'un système de transport hectométrique et l'analyse systémique adoptée par Ruth Heron dans l'évaluation du système Communicaid ne sont que trois exemples parmi plusieurs. Évidemment, en plus de ces méthodes formalisées de recherche appliquée, l'ergonomie comme toute autre discipline — droit, médecine, ingénierie, etc. — fait appel également à des méthodes et des pratiques heuristiques. Donc, tout compte fait, on peut dire que les ergonomistes qualifiés sont à la fois des théoriciens et des praticiens, dont le savoir-faire réside en partie dans le fait qu'ils savent exactement quelle méthode de recherche ou d'expérimentation utiliser, comment le faire et en tirer les réponses voulues aux problèmes posés.

How ergonomists spread their time between research and applied work is a question that, although not raised at the seminar, may be of more interest to members of the manager group, many of whom perhaps see human factors specialists as academics rather than as practitioners single-mindedly oriented to the world of production and business. Many Canadian ergonomists, of course, do have ties with universities, but they are attempting more and more to apply their knowledge and skills to real-life problems, to become more like their counterparts in Europe where applied ergonomics is well established and can stand profitably on its own. The seminar program was, in fact, intended partly to demonstrate not only ergonomists' interests in applied work but also the nature and diversity of relevant projects in which they have recently been involved.

However, as the content of earlier paragraphs implies, certain difficulties make for only slow progress in achieving the aim of increasing ergonomics activity in applied areas. To catch the flavour of these, perhaps we can touch again briefly on one already mentioned — the difference between the causal and probabilistic approaches to accident or error investigation. Under methodologies for the latter approach, a question such as "What is the cause of this accident?" would have to be rephrased as "What are the factors that contributed to a high probability of this accident's occurrence?" This different way of looking at problems is not a bother when the notion of complementary approaches is understood and accepted. However, when it is not understood, the ergonomist must explain how it can produce the information the client needs to solve his/her problem.

Il est cependant une question qui, si elle n'a pas été soulevée au cours de ce séminaire, n'en intéresse certes pas moins le groupe des gestionnaires qui, pour la plupart, perçoivent les ergonomistes plus comme des théoriciens que comme des praticiens partageant leurs préoccupations de productivité et d'économie. Il s'agit de la répartition du temps des ergonomistes entre la recherche pure et les travaux pratiques sur le terrain. Certes, de nombreux ergonomistes canadiens oeuvrent principalement en milieu universitaire mais, de plus en plus, ils cherchent à appliquer leur savoir et leurs techniques à l'étude de problèmes pratiques, en somme à suivre les traces de leurs homologues du continent européen où l'ergonomie appliquée est une profession bien établie et profitable par elle-même. En fait, le programme du séminaire avait été pensé, du moins en partie, dans l'optique d'une démonstration à faire non seulement de l'intérêt que portent les ergonomistes à l'ergonomie appliquée mais aussi de la nature très diversifiée des travaux auxquels ils ont récemment participé.

Cependant, comme les paragraphes qui précèdent le laissent entendre, il subsiste certaines difficultés qui expliquent la lenteur de l'évolution de l'ergonomie vers le statut de science appliquée. Pour illustrer la nature de ces difficultés, il peut être utile de revenir brièvement sur un sujet déjà abordé, soit la distinction à faire entre les approches causaliste et probabiliste à toute enquête sur un accident ou une erreur commise. Dans une approche probabiliste, une question comme "Quelle a été la cause de cet accident?" doit être reformulée comme suit : "Quels ont été les facteurs qui ont pu contribuer à la forte probabilité que l'accident se produise?". Mais du moment que la complémentarité des deux approches est comprise et acceptée, la différence entre les façons de considérer la question ne pose plus de difficulté. Lorsque cette complémentarité n'est pas comprise, il appartient à l'ergonomiste d'expliquer comment sa discipline peut parvenir à produire l'information dont le client a besoin pour résoudre le problème en cause.

Unfortunately, though, ergonomists often find their strategies and methodological approaches difficult to explain except in terms that may seem esoteric or academic. Pat Hallett referred to the barrier this sort of thing creates between engineers and ergonomists. And despite the considerable amount of progress he mentioned having been made in the last decade on both sides in overcoming it, there is obviously still much to be done to narrow the communication gap. Perhaps it behooves members of the newer discipline to try a little harder to ease this process.

Another problem ergonomists face is that, as Ron Kruk pointed out, they are often called in at the end of a project rather than at the beginning. As a consequence, not only are many of their powerful strategies never given a chance to be applied, but also — as some one remarked during the panel/audience discussion — what they then have to say appears to be nothing but criticism. A necessary step on the way out, of course, is to take up France Legault's suggestion of bringing ergonomists in at the start and making them part of multidisciplinary teams, as Intera did with Jerry Ells. It is only under these circumstances that they have an opportunity to explain how their various methodological tools can be applied to generate information that will facilitate design and development decisions and, hence, to minimize critical comment during evaluation at the end. This sort of arrangement will likely take place only gradually as more is understood about how ergonomists can fit into project teams and what they can produce. There is onus here on ergonomists to understand the transportation manager's concern with production costs and deadlines and with product marketability, to work carefully through the orientation stage until roles and deliverables can be clearly defined (as Jerry Ells reported doing with Star Vue) and, most importantly, to demonstrate how what they contribute will be cost effective.

Malheureusement, les ergonomistes ont souvent de la difficulté à décrire leurs techniques dans des termes qui sortent du jargon qui leur est propre. Pat Hallet a fait allusion à la barrière que cela peut créer entre ingénieurs et ergonomistes. Un énorme progrès a été fait au cours de la dernière décennie pour abaisser cette barrière, mais il reste encore beaucoup à faire. Peut-être serait-il normal que les adeptes de cette nouvelle science, l'ergonomie, s'y mettent davantage.

Un autre problème auquel les ergonomistes doivent faire face, d'après Ron Kruk, est que souvent l'ergonomiste n'est appelé à intervenir dans un projet que sur le tard, à un moment où, comme l'a fait remarquer quelqu'un, ses opinions paraîtront aux autres comme autant de critiques. La meilleure parade serait, bien sûr, de suivre la suggestion faite par France Legault, à savoir faire appel à l'ergonomiste dès le début du projet, comme l'a fait Intera avec Jerry Ells. L'ergonomiste aura alors l'occasion d'expliquer à ses collègues comment les techniques qu'il entend mettre en oeuvre peuvent fournir l'information utile à la prise de décisions concernant la conception ou la mise au point et éviter ainsi de leur laisser une impression fâcheuse. Mais cette évolution ne prendra forme que graduellement, à mesure que l'on se rendra compte du rôle que peut jouer l'ergonomie dans un projet d'étude, grâce à l'information qu'elle peut produire. De leur côté, les ergonomistes doivent s'efforcer à comprendre la position des gestionnaires en transport qui ont à composer avec des budgets, des échéanciers et des contraintes de commercialisation, à user de prudence durant l'étape des études préliminaires, comme le signale Jerry Ells à propos du Star-Vue, jusqu'à ce que les tâches et les produits livrables aient pu être clairement définis et, surtout, à démontrer leur apport à la rentabilité du projet.

Still another problem for ergonomists relates to the concern David Lewis mentioned — namely, that because of the multidisciplinary nature of ergonomics, standardization of research methods may be lacking. This is a legitimate concern — it is quite understandable that the very diversity of disciplines under the ergonomics umbrella may tend to lead to the impression that it is an uncoordinated science. The scientific method is of course universal, and so it can be said safely that, regardless of the discipline, research methods are uniform. However, when it comes to applied work — and it is this work that was the focus of the seminar — it is certainly true that each discipline has its own set of methodological approaches. What unifies these approaches with respect to ergonomics is that they are all underlain by the information-processing model and its necessarily systems-oriented view. Perhaps the real problem here for the transportation manager is knowing, first, what type of ergonomist to select for a given project and, then, who among the list of possibles is bona fide. Unfortunately, because ergonomists are not licensed — as are lawyers, engineers, and even psychologists — it can frequently be the case that wholly unqualified people are hired to do their work. Apart from resulting in service that is less than optimal, this practice contributes to an image of ergonomics as lacking in scientific rigour and uniformity. Offsetting it is the fact that HFAC/ACE and affiliated societies (eg. the Ergonomics Society in the U.K., the Société d'Ergonomie de la Langue Française in Europe and the Human Factors Society in the U.S.) all have rather stringent requirements for full membership, and these are still greater for higher levels such as admission to professional register. Thus, the prospective client is afforded at least some degree of protection.

Par ailleurs, comme l'a souligné David Lewis, l'ergonomie, de par sa nature multidisciplinaire, met en oeuvre des méthodes de recherche qui ne sont pas normalisées. Les inquiétudes que cela soulève sont tout à fait légitimes, étant donné que, devant la vaste gamme de disciplines que l'ergonomie englobe, l'impression qui se dégage est qu'il s'agit d'une science plutôt désorganisée. La méthode scientifique est, bien sûr, universelle et l'on peut dire sans risque de se tromper que, sans égard aux disciplines, les méthodes de recherche sont partout uniformes. Cependant, sur le plan de la recherche appliquée — et c'est là le sujet central de ce séminaire — il est certain que chaque discipline utilisera un ensemble de techniques différentes. La seule chose qui les apparente à l'ergonomie est le fait que ces techniques s'inspirent du modèle fondé sur le traitement de l'information et de l'approche systématique qui est le propre de l'ergonomie. Il se peut donc que le vrai problème pour le gestionnaire en transport soit de déterminer d'abord laquelle des disciplines propres à l'ergonomie il faudra mettre en oeuvre et, ensuite, qui est le plus qualifié parmi les spécialistes de cette discipline. Malheureusement, étant donné que les ergonomistes ne sont pas tenus de détenir un permis d'exercer comme les avocats, les ingénieurs et même les psychologues, il arrive fréquemment que des personnes sans aucune qualification se fassent admettre comme des ergonomistes attitrés. En plus de fournir des services de qualité douteuse, ces personnes ternissent l'image de l'ergonomie et la présentent comme étant dénuée de rigueur scientifique et de cohérence. Heureusement que l'Association canadienne d'ergonomie et d'autres organismes compétents comme la Ergonomics Society du Royaume-Uni, la Société d'ergonomie de la langue française en Europe et la Human Factors Society aux États-Unis imposent, à ceux qui veulent en devenir membres, des conditions d'admission très sévères et plus encore à ceux qui veulent exercer la profession. Ainsi, la clientèle est assurée au moins d'un certain degré de protection.

The foregoing bears to some extent on the query, posed by an unidentified person at the seminar, regarding whether ergonomics is not all just common sense, or at least readily obtainable from a text book — *ergo*, couldn't any one practise it? Ron Kruk's response, in which he talked of levels of practice, was to the point. We paraphrase his reasoning. At a first level, it is clear that we need no more than common sense to tell us that, if a work station is to be designed, a chair and a desk are needed. But the application of 'standards' to arrive at 'correct' dimensions is anything but straightforward, although numerous texts citing standards may give the impression that it is.

Ceci répond à la question posée par un intervenant qui ne s'est pas identifié et qui se demandait si l'ergonomie n'était pas un exercice de bon sens, sinon une "science" que l'on peut puiser dans les manuels techniques. En d'autres termes, n'est-elle pas ouverte au premier venu? Dans sa réponse pleine de pertinence, Ron Kruk a parlé de niveau professionnel. Si l'on se rappelle ses propos, le bon sens nous dit qu'un poste de travail nécessite une chaise et un bureau; mais savoir se servir de normes pour dimensionner ces objets n'est pas si simple que cela, malgré tout ce que peuvent laisser croire certains textes à cet égard.

At still higher levels — where there are complex inputs to the brain as is the case in the air traffic controller's task being studied by Paul Stager, where the biomechanics involve more than simple movements of the body, or where any of the human/machine interactions are complex and/or undefined — using only common sense may be not just inappropriate or non-inclusive, but dangerous. Unfortunately, it is often in these cases that the need for specialized expertise is unrecognized. In his presentation, Jerry Ells remarked on the facetiously expressed suggestion of the Intera group that their experience with him on the Star Vue project had left them capable of carrying on without him in the next phase. We know, of course, that they did ask Jerry back, their decision to do so surely indicating their awareness of the depth and quality of his input. Discerning what types of problems require the application of high-level ergonomics expertise will undoubtedly become easier with time through experiences like Intera's.

À un niveau encore plus élevé — exemple les stimuli complexes perçus par le cerveau d'un contrôleur de la circulation aérienne, cas étudié par Paul Stager, où l'étude biomécanique va au-delà des simples mouvements du corps et où toutes les interactions homme-machine sont soit complexes, soit mal définies — l'application du simple bon sens peut être inadéquate, sinon dangereuse. Malheureusement, c'est généralement dans ces cas que l'on choisit de se passer de la personne dont c'est la spécialité. Dans son exposé, Jerry Ells racontait que le groupe Intera lui avait signifié, à la blague, qu'il n'avait plus rien à apprendre à propos du système Star-Vue et qu'il avait décidé de se passer de ses services pour l'étape suivante. Nous savons cependant que Jerry a été rappelé, ce qui montre sans doute qu'Intera se rendait bien compte de la valeur et du caractère indispensable de l'apport de ce dernier. Il est probable qu'avec le temps, et grâce à des expériences comme celle d'Intera, il deviendra de plus en plus facile de déterminer les types de problèmes auxquels l'ergonomie de pointe est susceptible de convenir.

Apart from comments suggesting gaps in information regarding the practice of ergonomics, there were many others from the manager group regarding its value to the transportation field. For example, in his opening remarks, Ted Rudback drew attention to the fact that ergonomics cuts across

En contrepartie des intervenants ayant souligné les idées préconçues que les spécialistes des transports pouvaient avoir au sujet de l'ergonomie et de ses applications, il y a eu plusieurs personnes, venant de ce même groupe, qui ont mis en évidence l'apport de l'ergonomie au domaine

areas representing the "driving technologies" and "disciplines that make things happen" in transportation development. Roy Nishizaki referred to its role in improving the safety and efficiency in the movement of people within our transportation system and in opening up access to our elderly and disabled citizens, while David Lewis spoke of its potential for contributing to resource savings in the economy and for bringing about improved productivity. Others remarked that the seminar had shown that there were very many areas in transportation to which ergonomics can be applied, including those classed as high technology. For addressing the overall problem of how ergonomics fits into the scheme of things in the field of transportation, we are very much taken by Marc Brenckmann's analogy in which he sees it as a wrench that fits "certain fairly tight and obstinate nuts", these representing problems that could not otherwise be resolved. His added comment, to the effect that it had only just begun to show its benefits, alerts us to the fact that much must be done to render these benefits fully realized. We hope all who attended will regard the October 1987 seminar as a stimulating, fruitful, and promising beginning.

Ruth M. Heron, Ph.D., M.Erg.S.
(Chairperson)
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Transportation Ergonomics Seminar

particulier des transports. Par exemple, dans son allocution d'ouverture, Ted Rudback a fait valoir que l'ergonomie puise dans toutes les disciplines dites "de base", celles qui sont à l'origine du progrès dans le domaine des transports. De son côté, Roy Nishizaki soulignait le rôle de l'ergonomie dans l'amélioration de la sécurité et de l'efficacité des transports en général et dans leur adaptation de plus en plus grande aux personnes âgées et aux handicapés. Pour sa part, David Lewis a parlé de l'utilité de l'ergonomie lorsqu'il s'agit d'économiser les ressources du pays et de relever la productivité générale. D'autres intervenants ont insisté sur le fait qu'il existe de nombreux créneaux de transport où l'ergonomie pourrait être utile, y compris ceux qui sont considérés comme relevant de la haute technologie. Mais l'intervention qui nous a le plus frappé à propos du rôle que pourrait jouer l'ergonomie dans les transports a été celle de Marc Brenckmann où celui-ci assimile l'ergonomie à une clé anglaise qui permet de "desserrer certains écrous grippés et récalcitrants". En d'autres termes, qu'il y aurait des types de problèmes que l'ergonomie seule pourrait résoudre. Et lorsqu'il déclare que celle-ci n'en est vraiment qu'à ses débuts, on conçoit qu'il reste encore beaucoup à faire avant qu'elle ne puisse réaliser son plein potentiel. Nous espérons que tous ceux qui ont participé au séminaire sur l'ergonomie d'octobre 1987 en garderont l'impression que tout cela n'est effectivement qu'un début : stimulant, fructueux et plein de promesses.

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